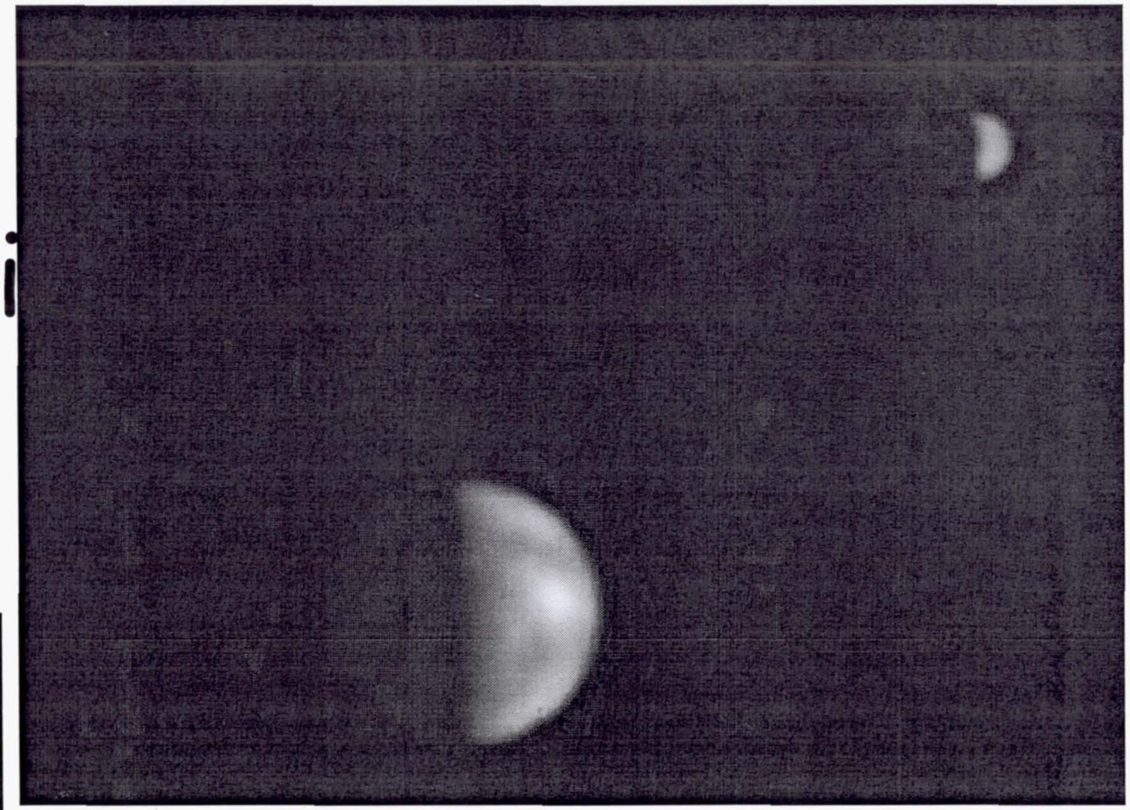
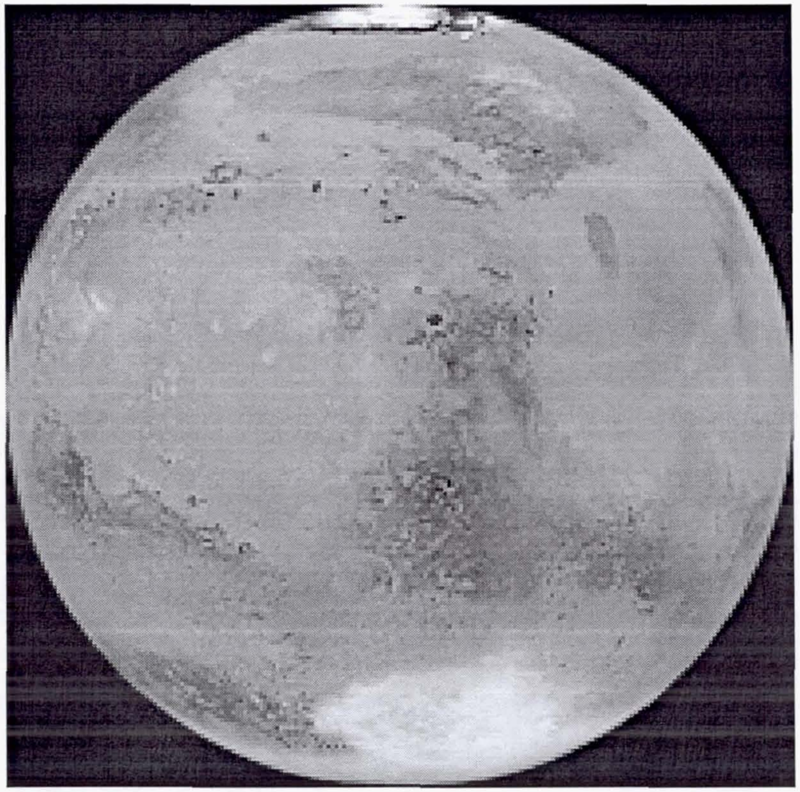
Lewis & Clark

- On the 27th anniversary of the Declaration of Independence, in 1803 President Thomas Jefferson commissioned a "Corps of Volunteers on an Expedition of North Western Discovery"
- One day later, Meriwether Lewis set out from Washington, DC to find an all-water route across the continent to the Pacific Ocean
- The following May of 1804, in the region of St. Louis (the staging area for the journey of discovery) Meriwether Lewis met co-commander William Clark and began the actual exploration

Blazi





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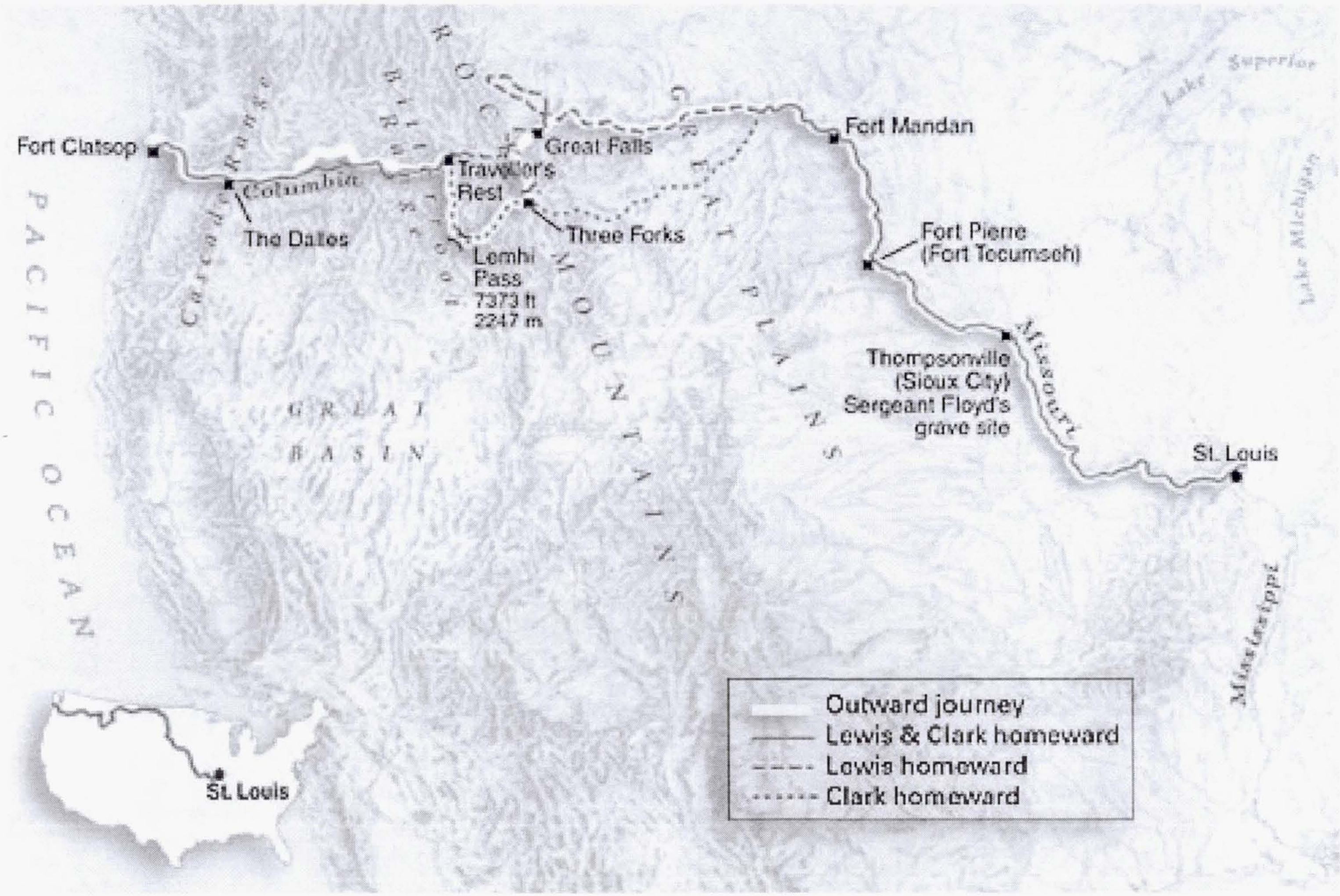
Space & Life Sciences Directorate
NASA Johnson Space Center
June 2004

200th Anniversary Lewis & Clark Expedition



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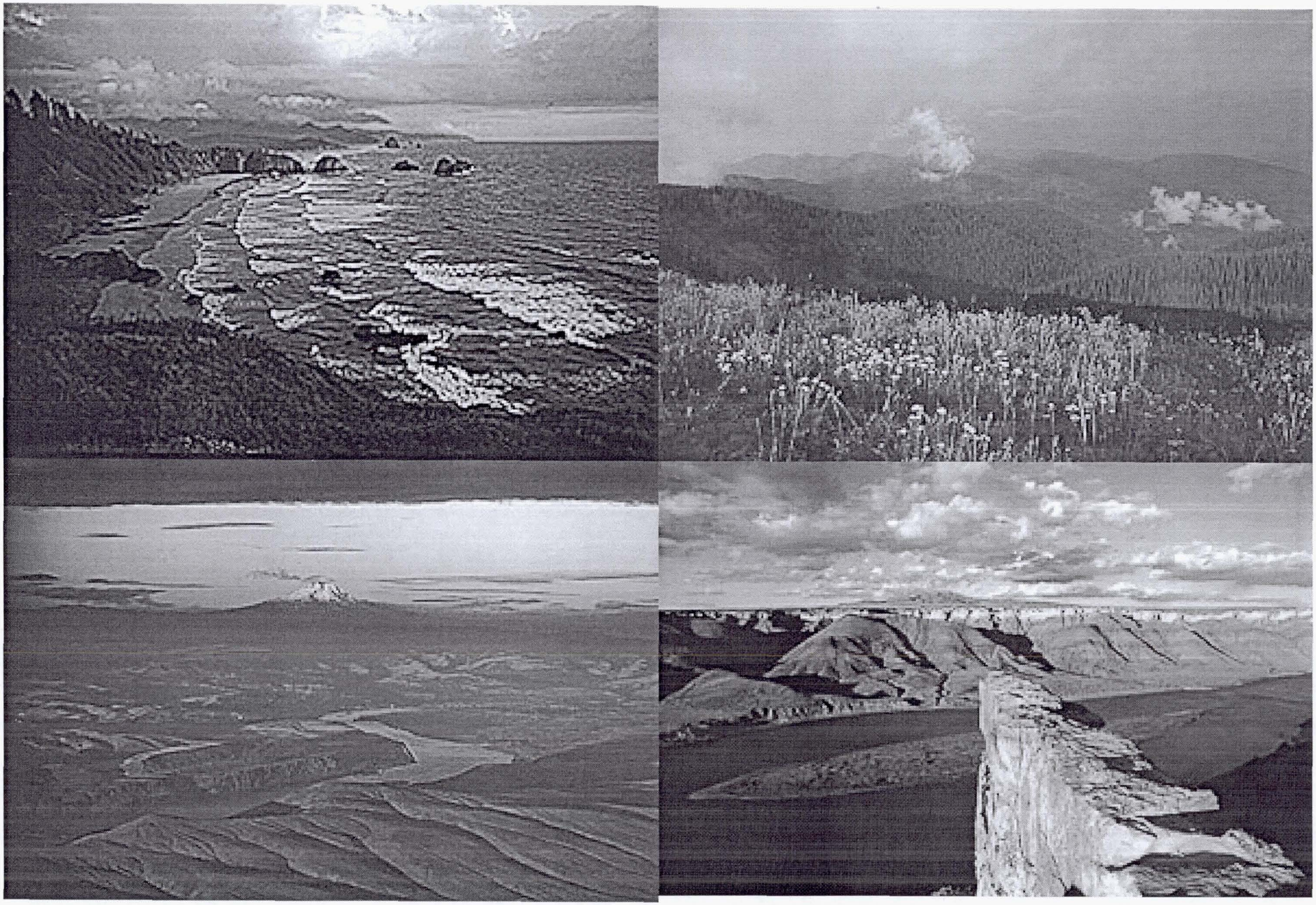

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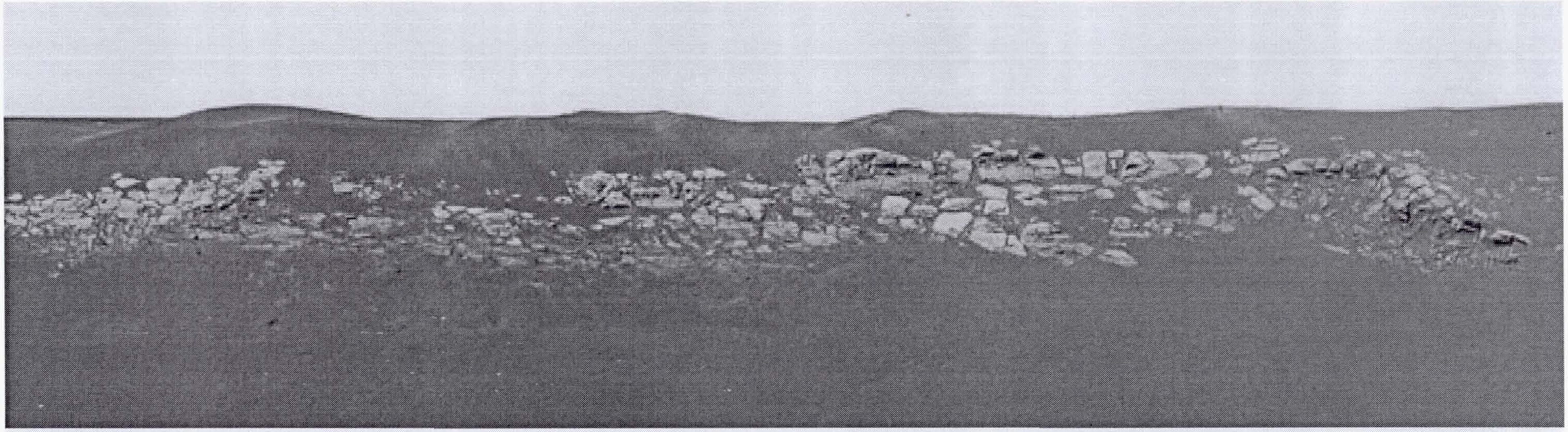
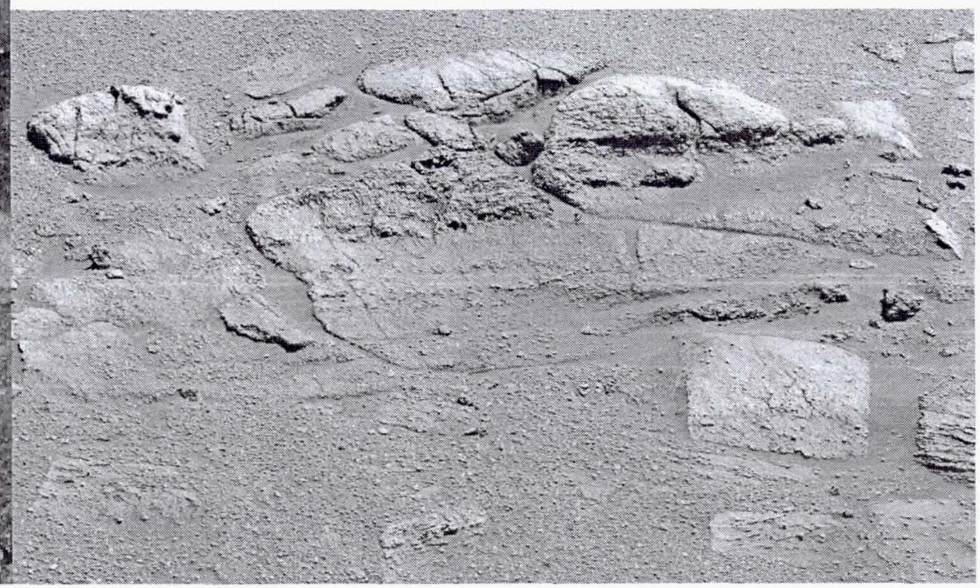
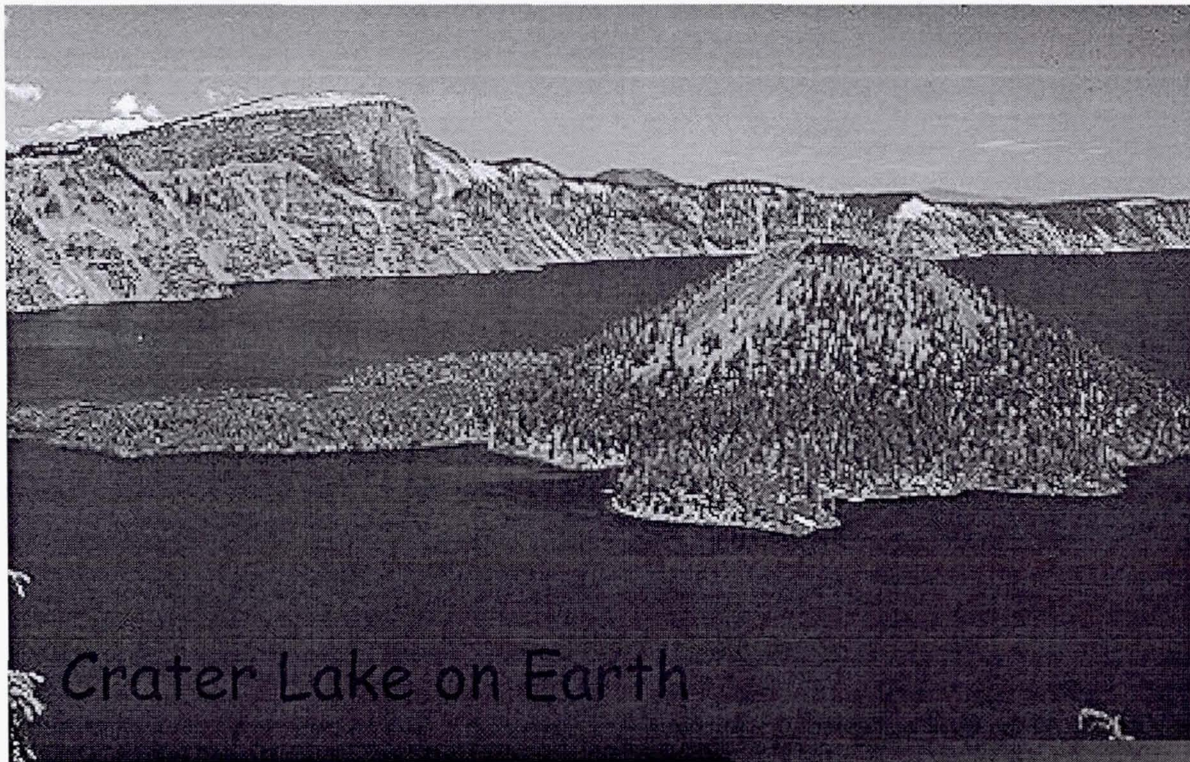
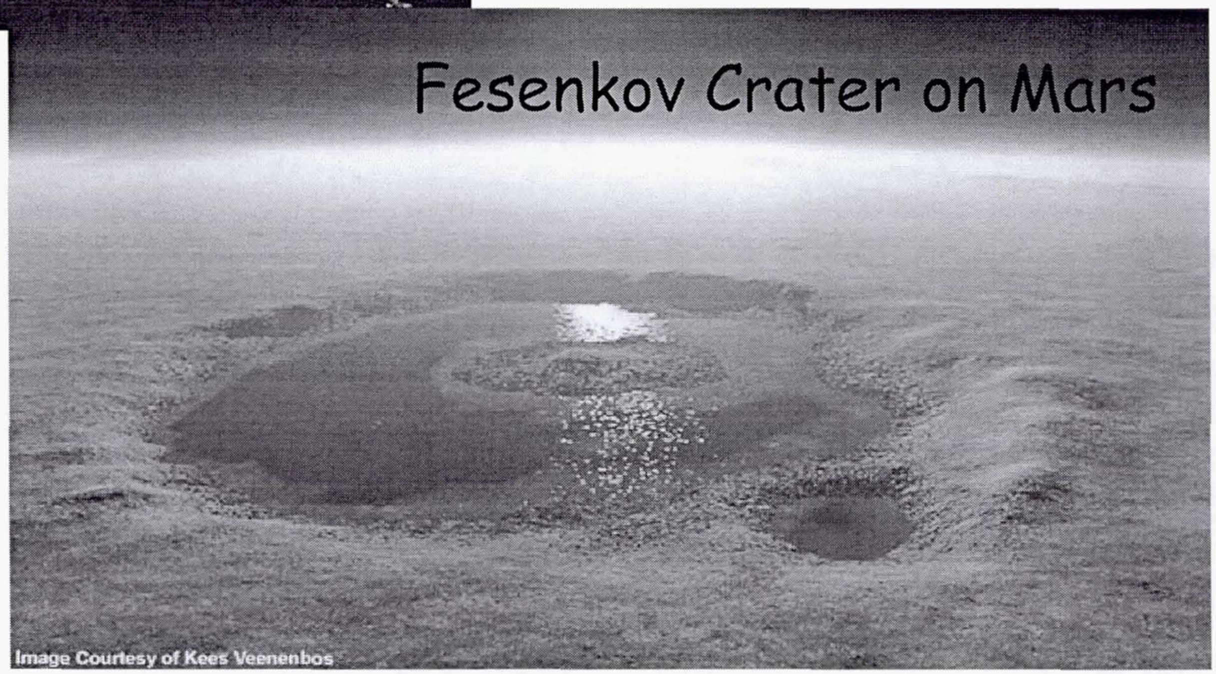


"El Capitan"
Guadalupe Nat'l Park, Texas

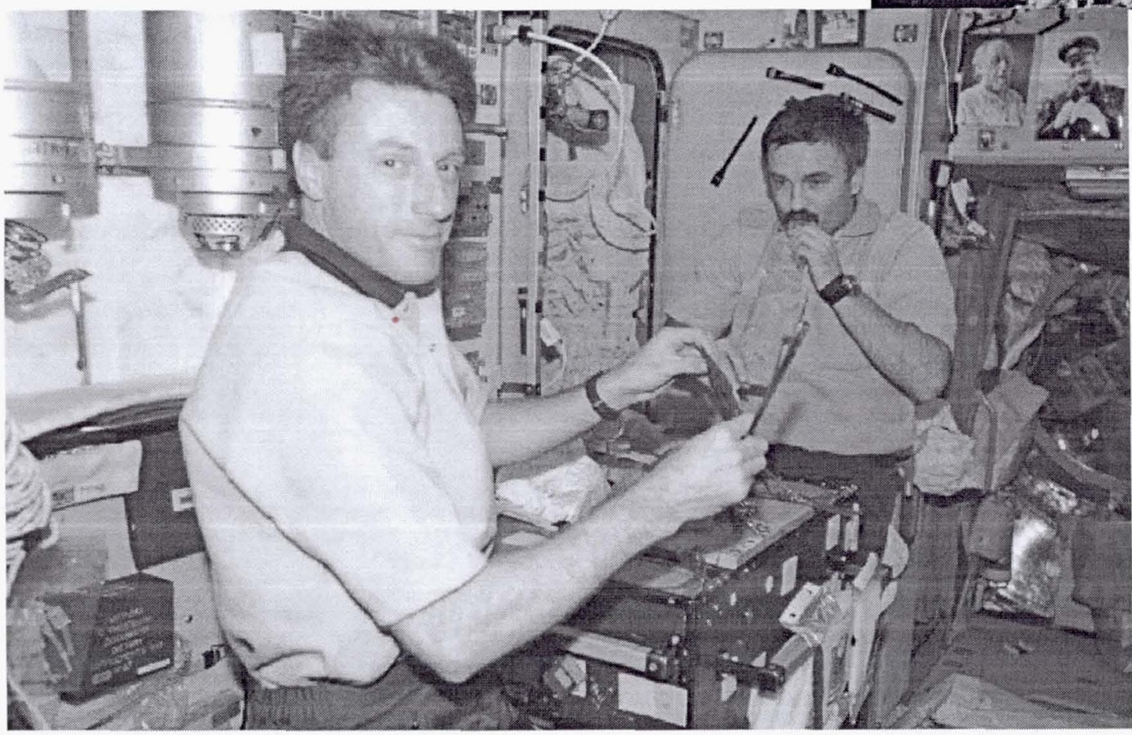
"El Capitan"
Mars




Crater Lake on Earth

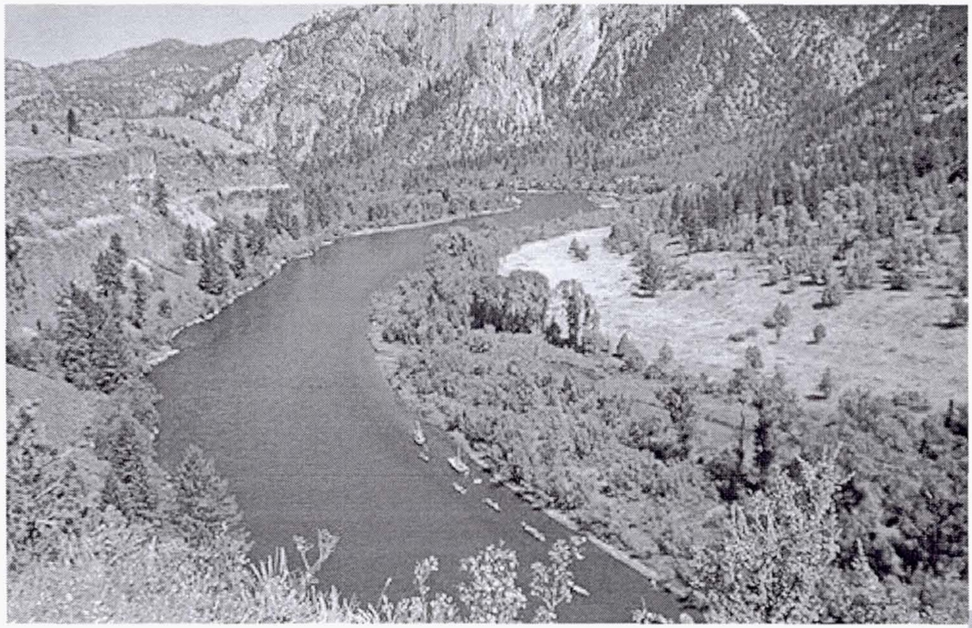

Fesenkov Crater on Mars
Image Courtesy of Kees Veenenbos

For Lewis & Clark eating was feast or famine, with periods of plentiful food supplies and periods of near starvation.



For astronauts, carefully designed nutritious meals of known composition are provided. The problem in space is not eating what is available.

Similarities



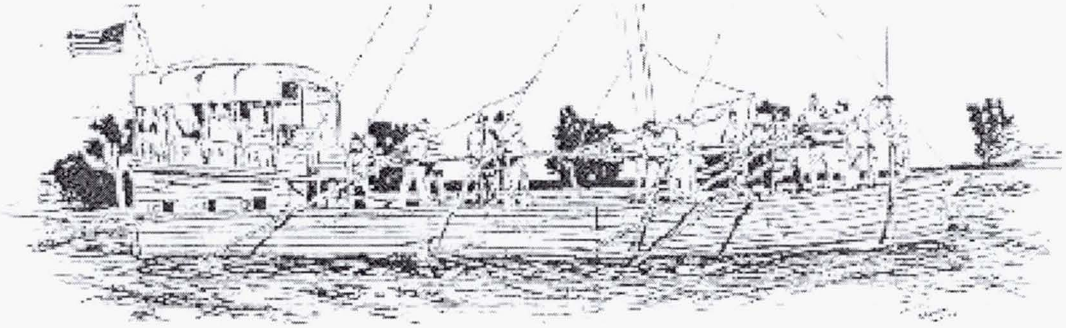
Lewis & Clark

- Explored the unknown
  - Western North America
- Uncovered nature's mysteries
- Recorded results
- Preplanned extensively
- Carried all supplies, except food
- Trained generally

Astronauts

- Explore the unknown
  - Space
- Uncover nature's mysteries
- Record results
- Preplan extensively
- Carry all supplies, including food
- Train specifically

Differences

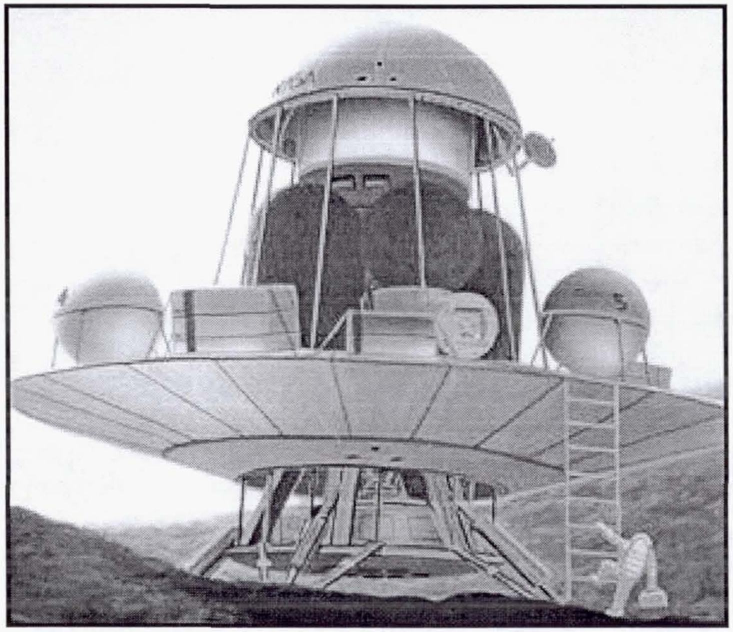


Lewis & Clark

- No outside communication
- Ability to modify route
- Boats, horses, or foot
- Casual team selection (except for leader)
- 0 to 50 miles/day

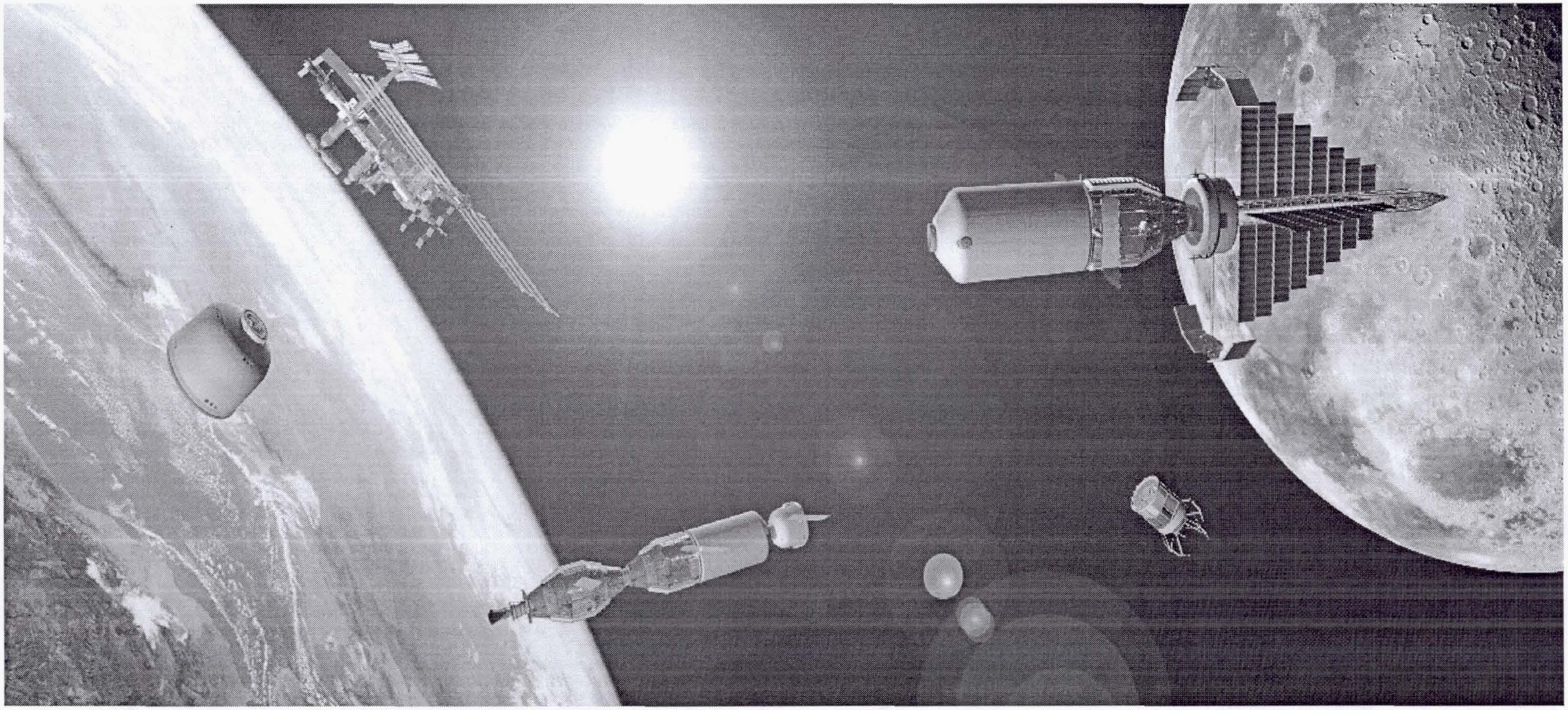
Astronauts

- Continuous communication
- Postlaunch, a set course
- One transportation mode
- Rigorous team selection
- 420,000 miles/day

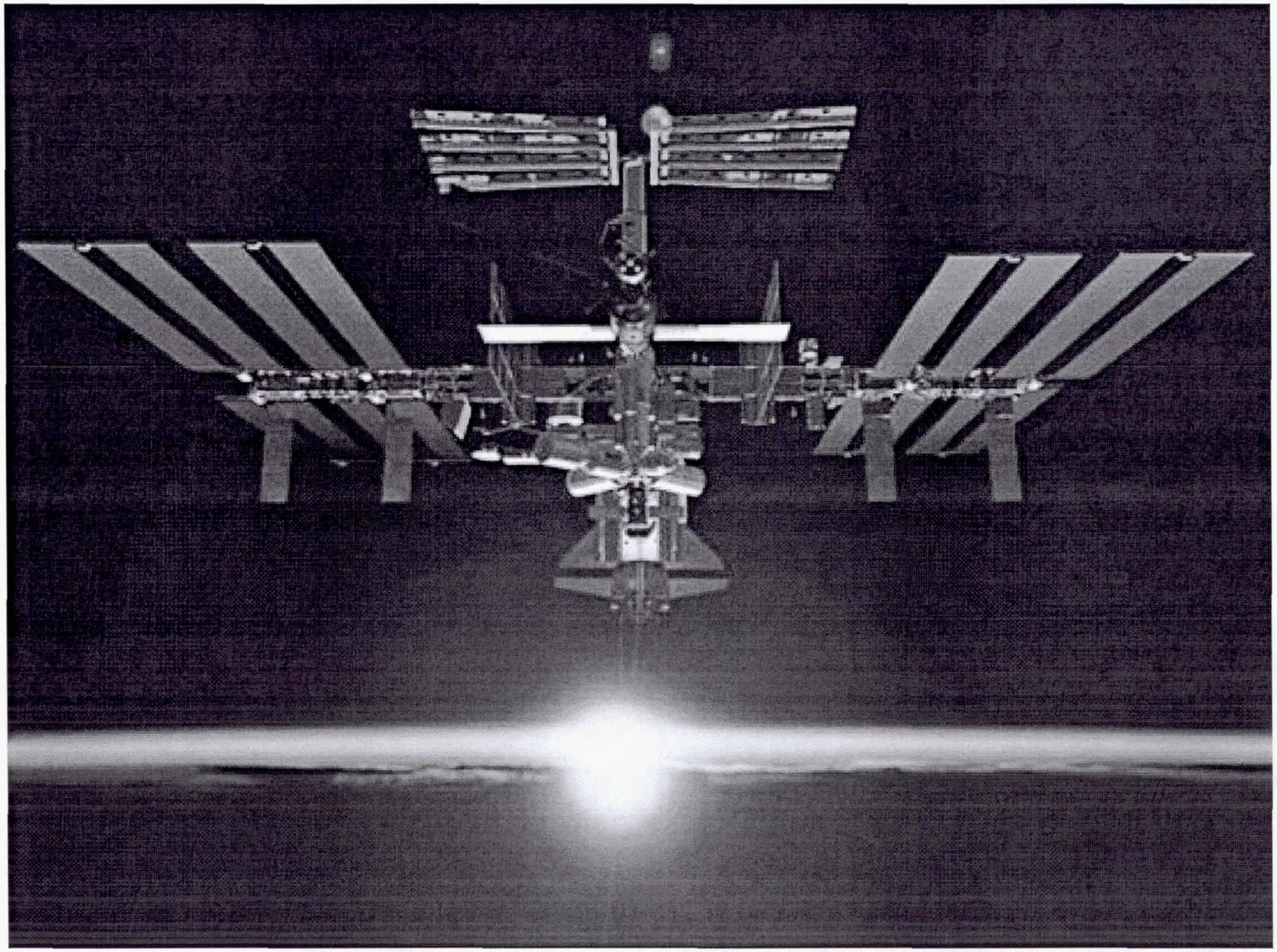


The Vision for Space Exploration

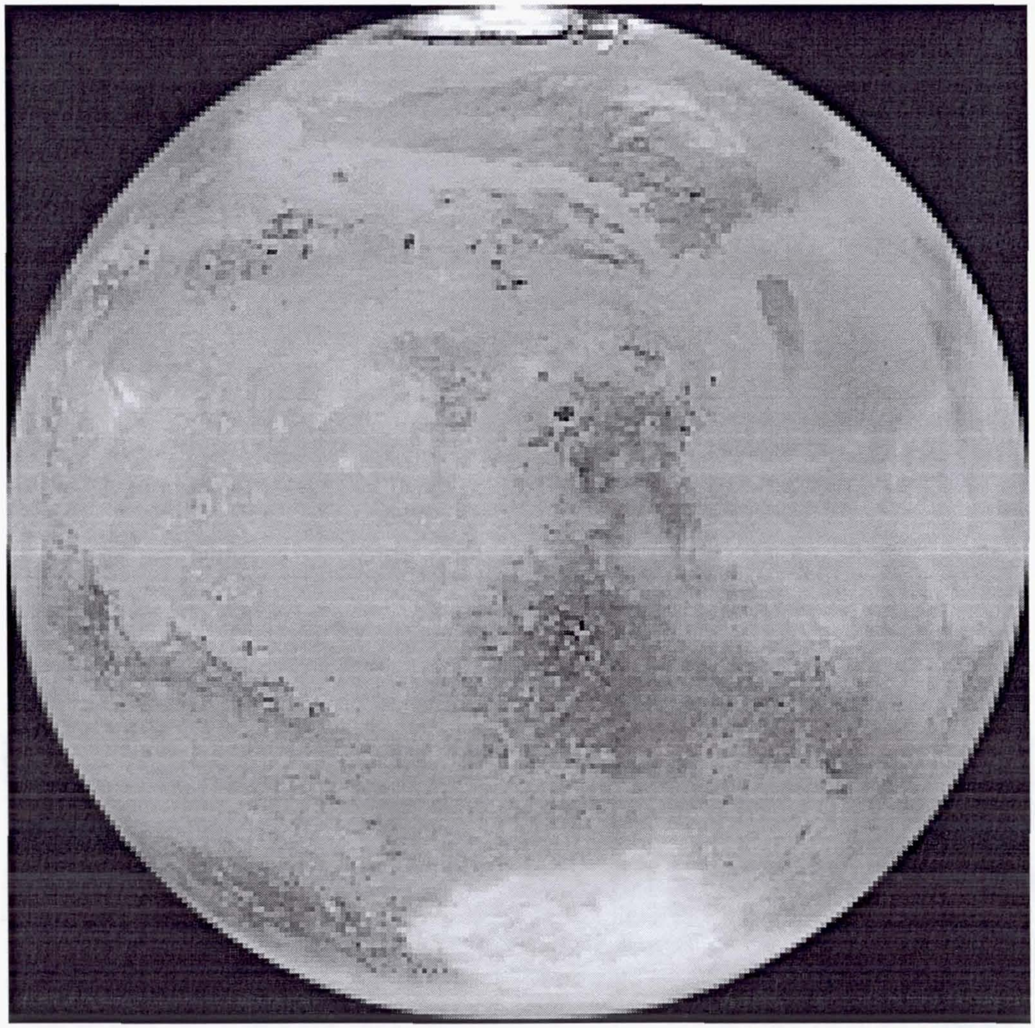
"This cause of exploration and discovery is not an option we choose;
it is a desire written in the human heart."
President Bush – January 14, 2004



Complete ISS Assembly ~ 2010



Mars Lander Mission ~ 2011



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Humans Land and Explore the Moon ~ 2015-20

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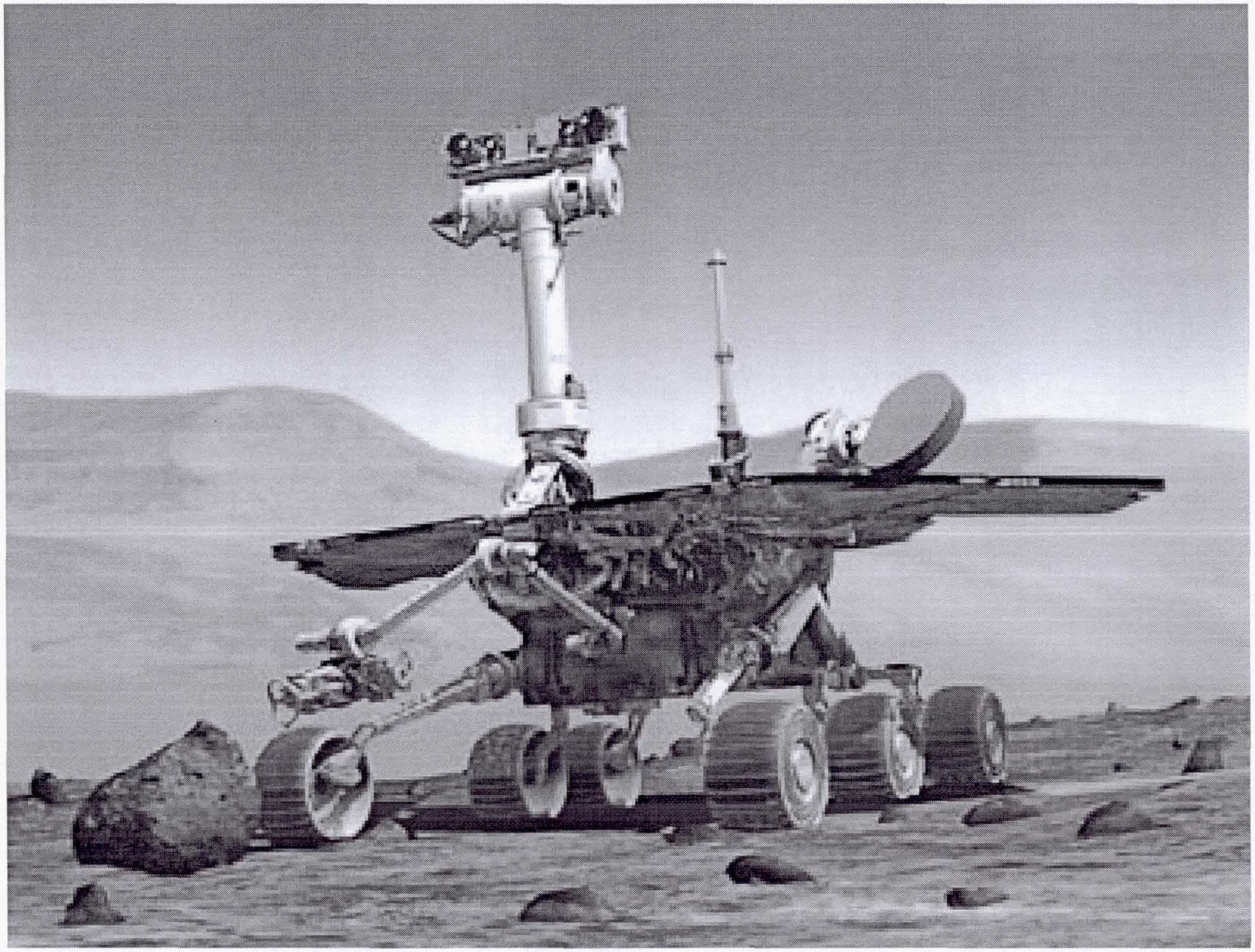

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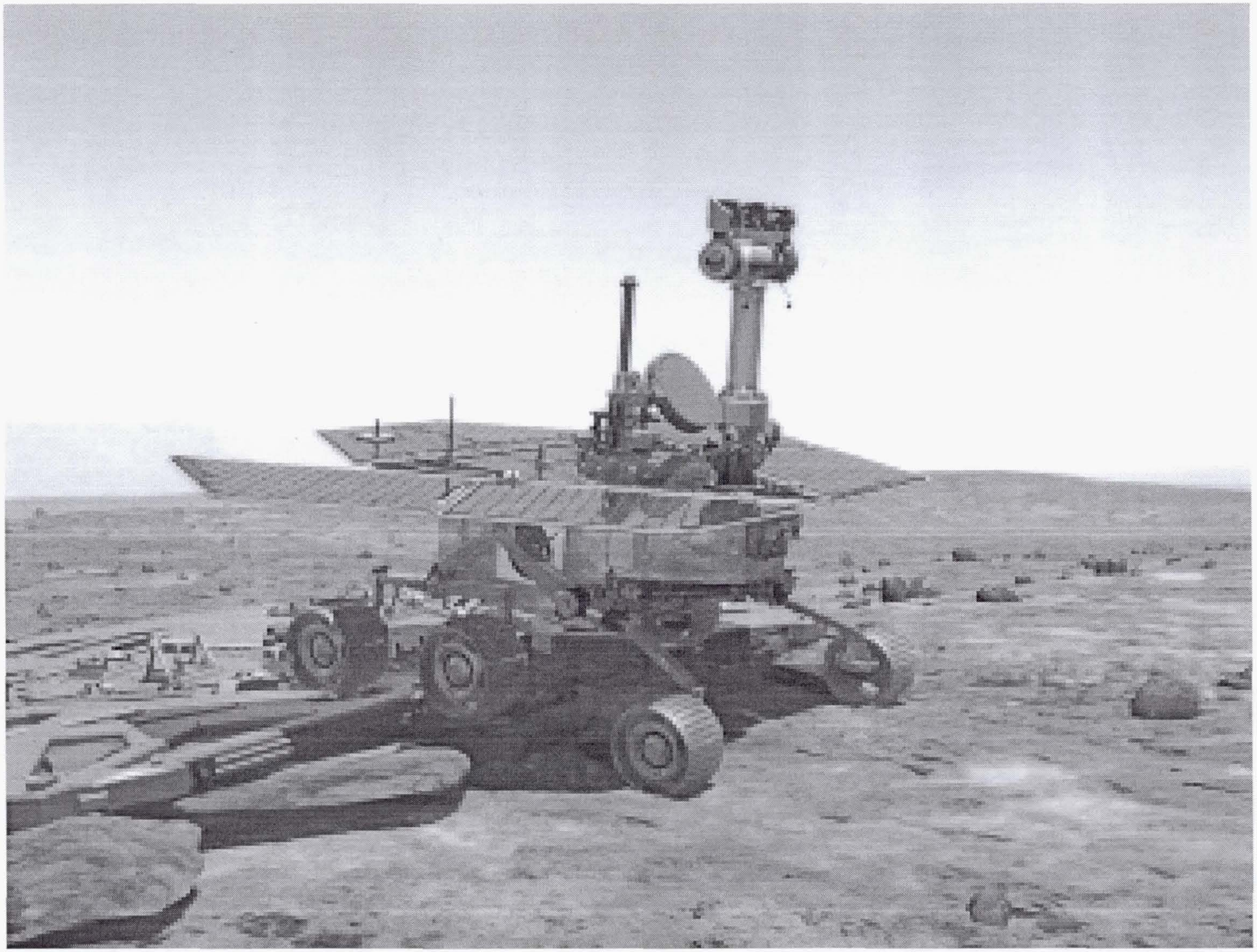

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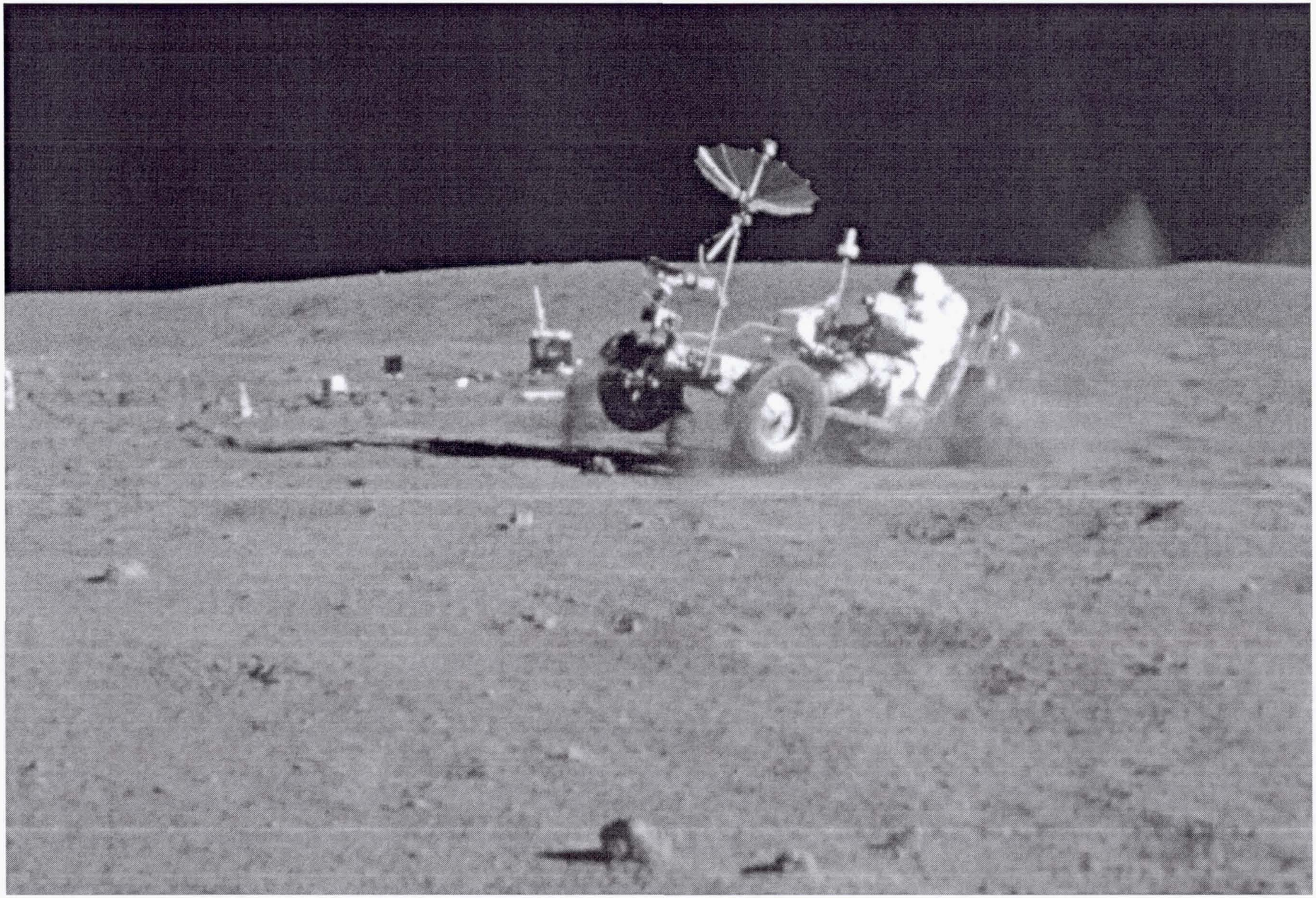
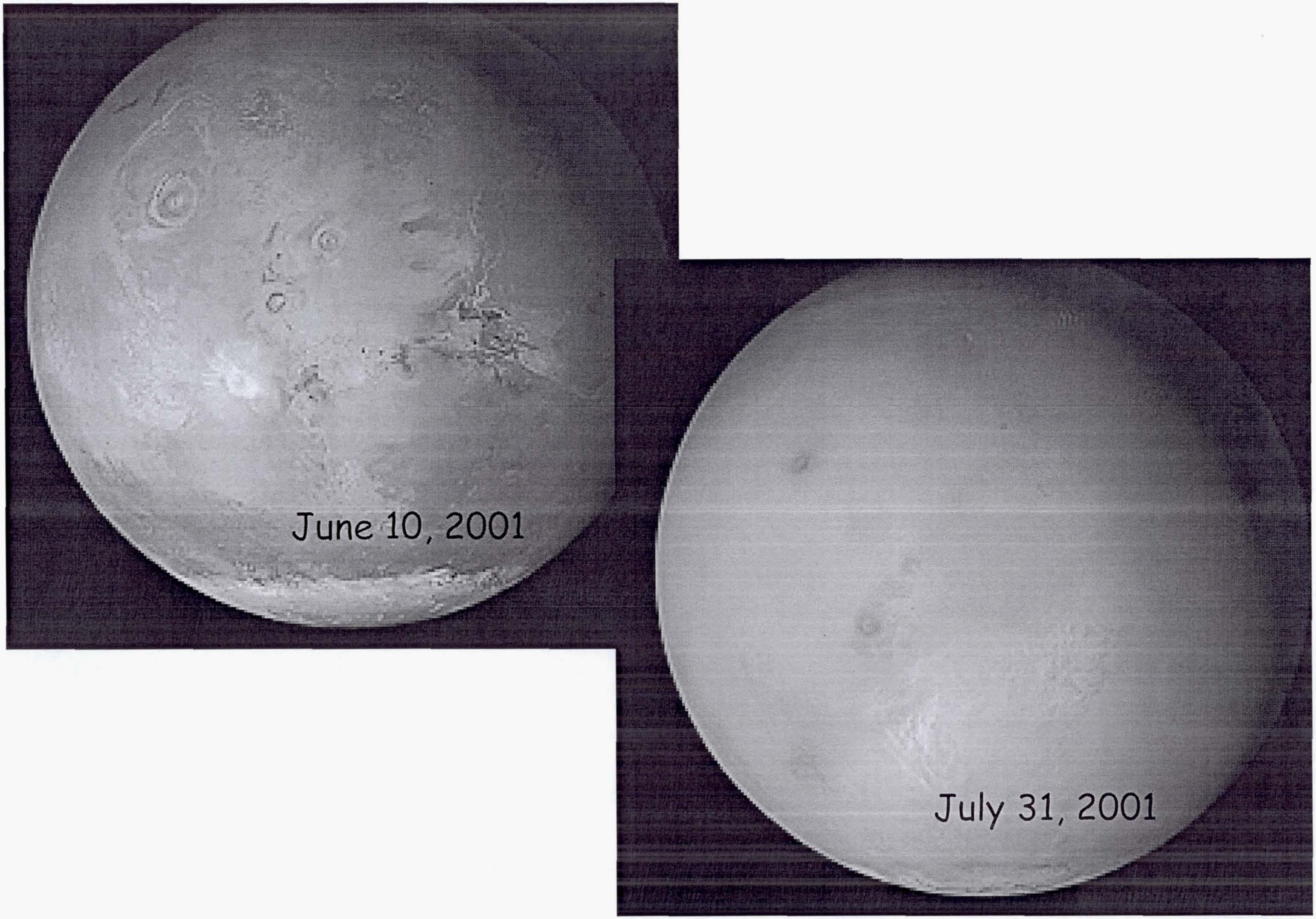
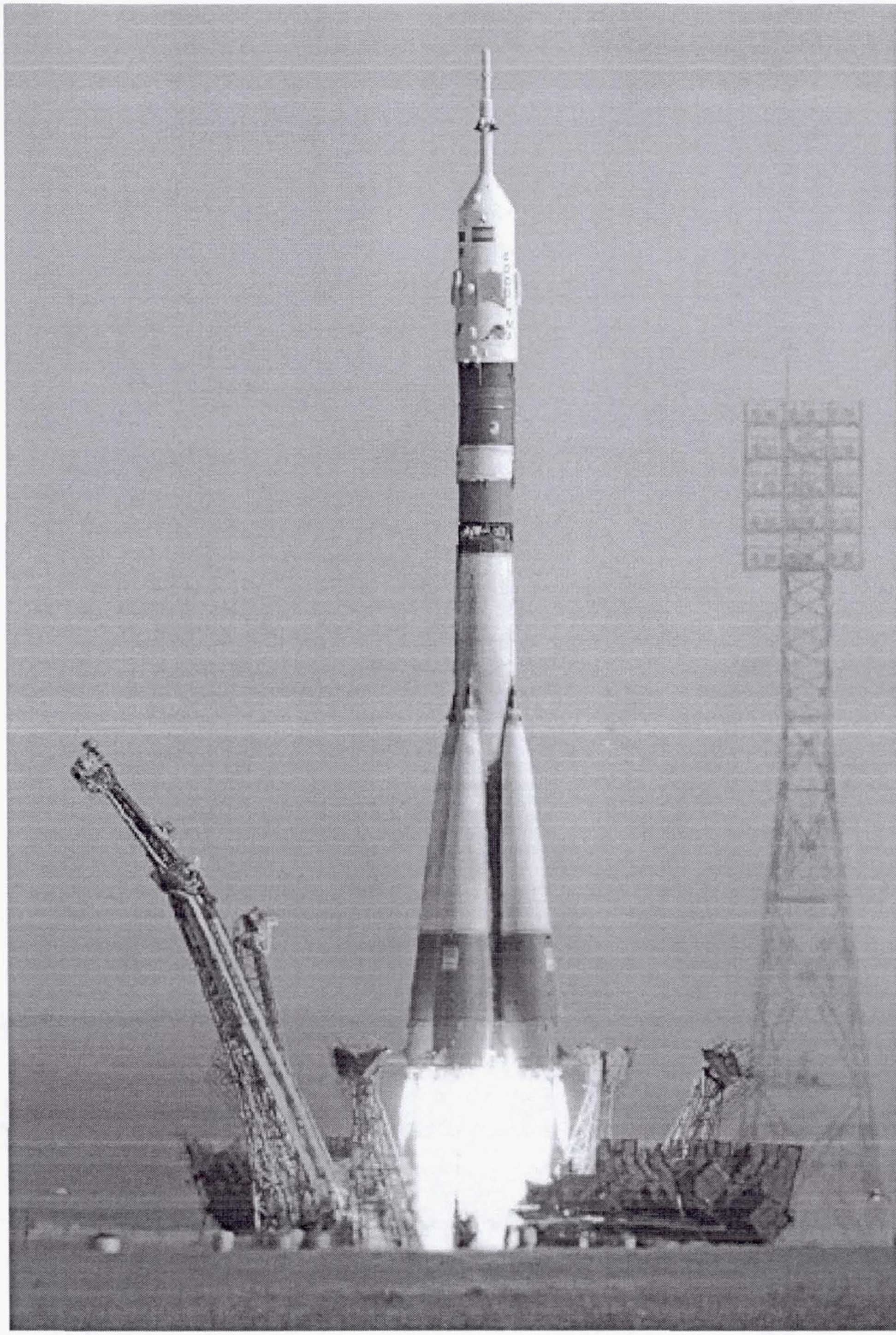
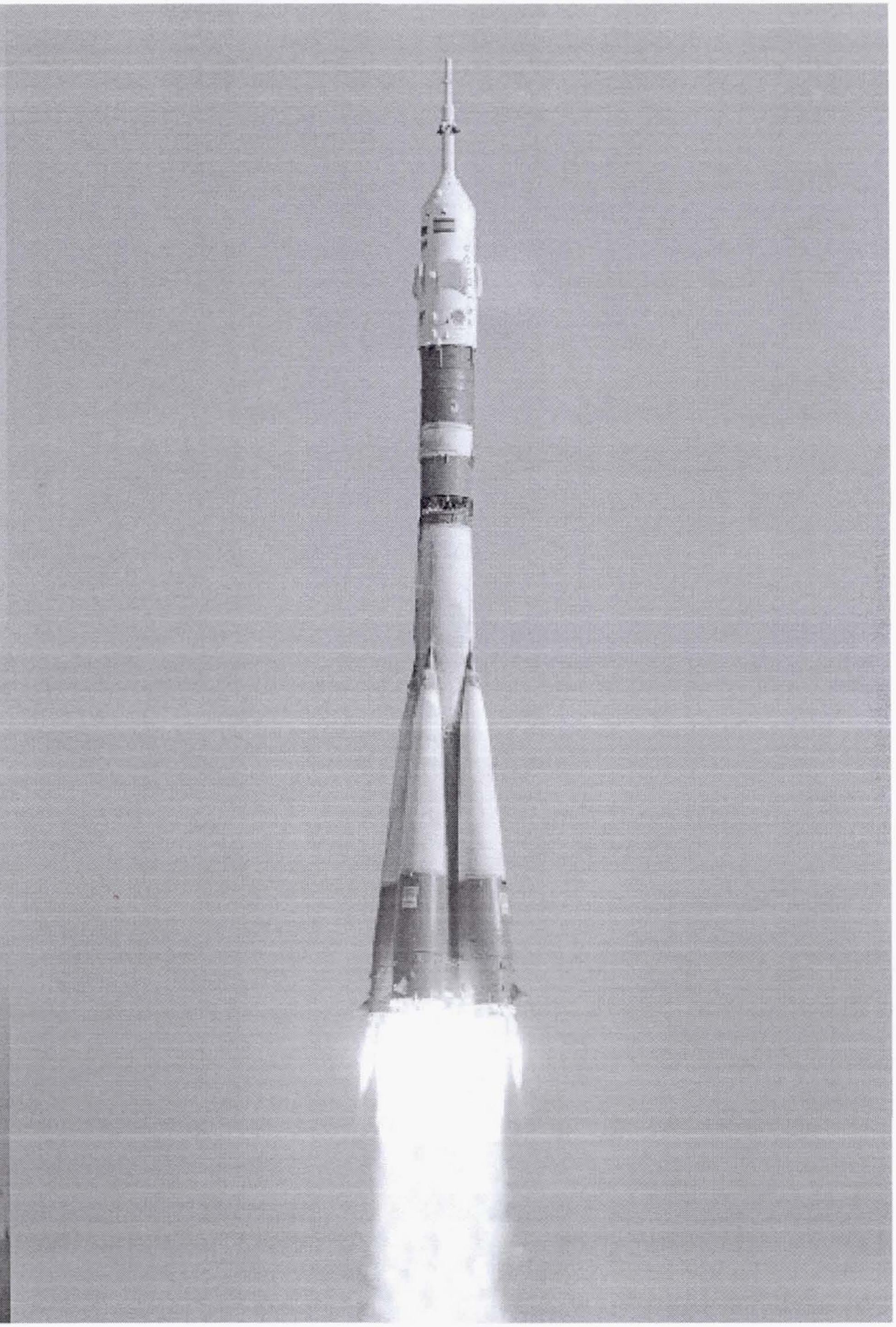
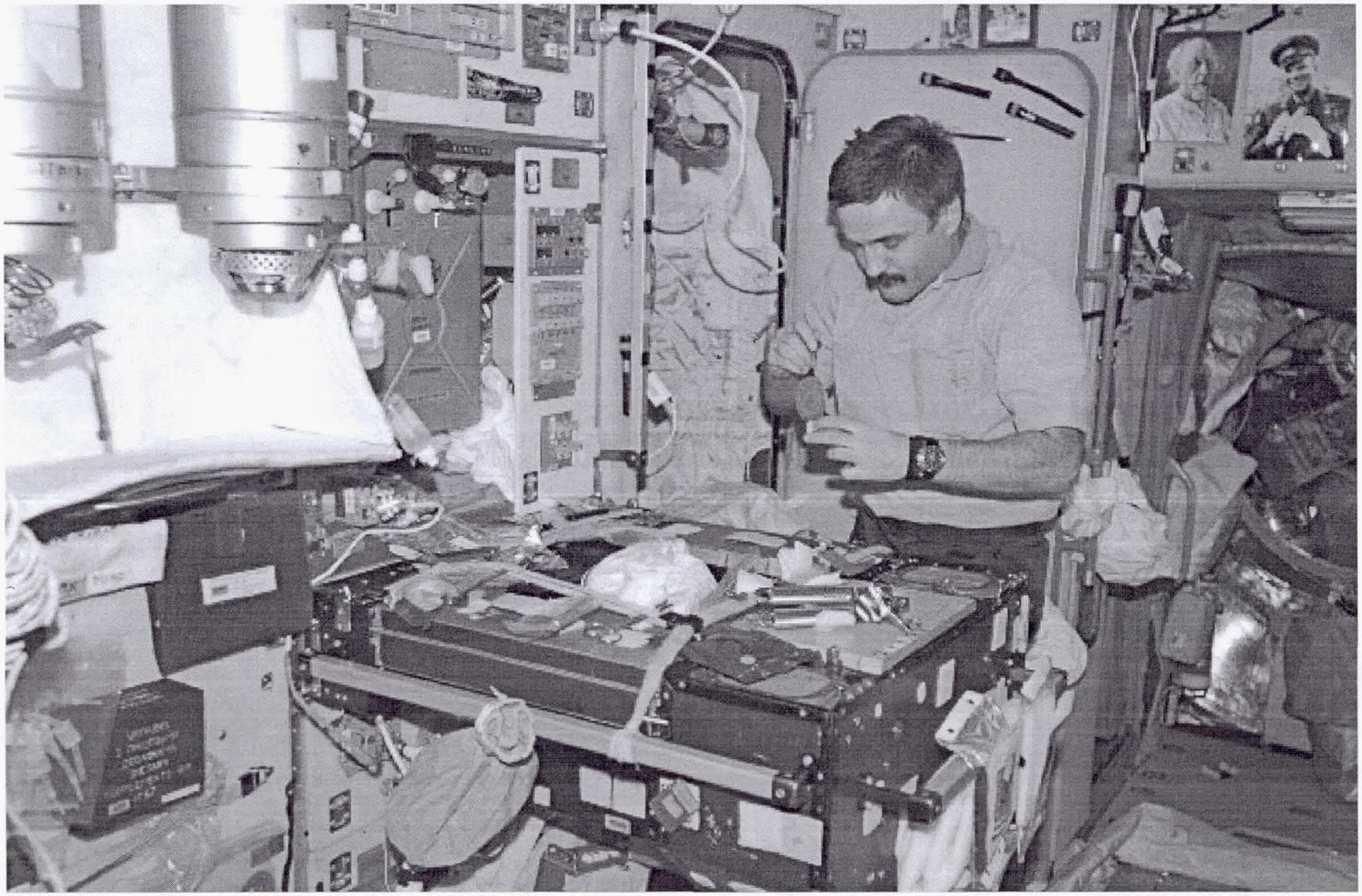
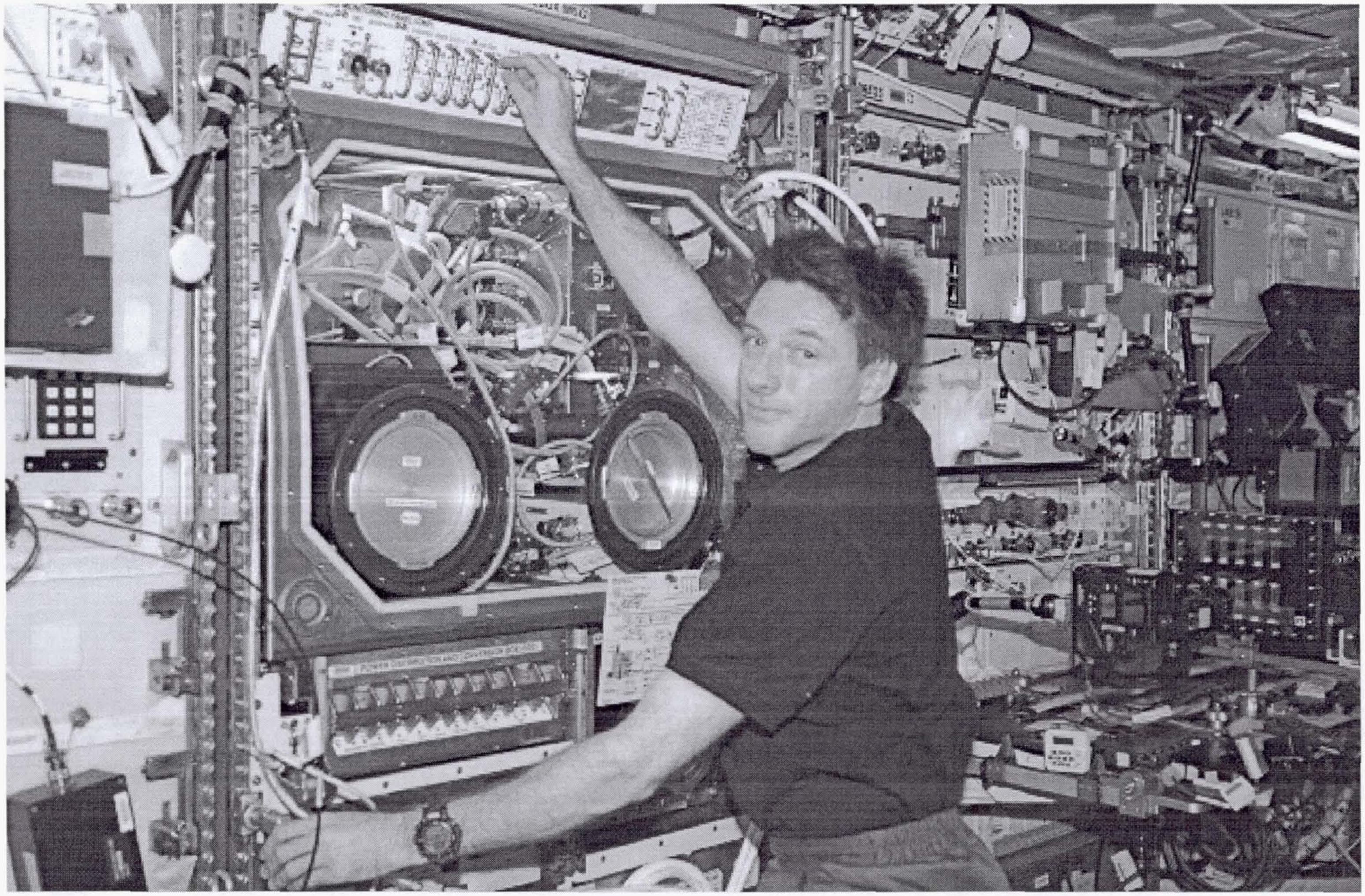



June 10, 2001
July 31, 2001









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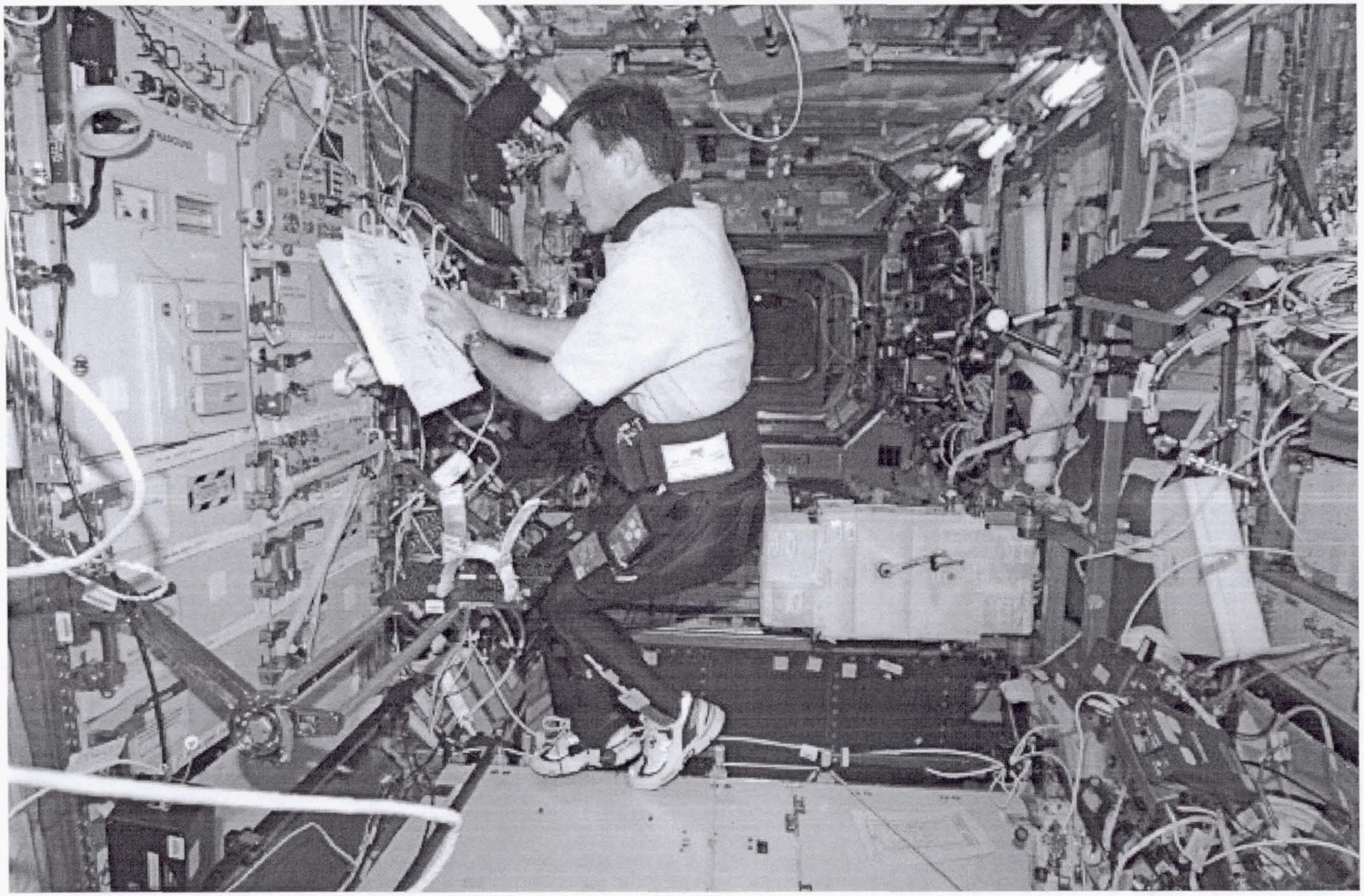

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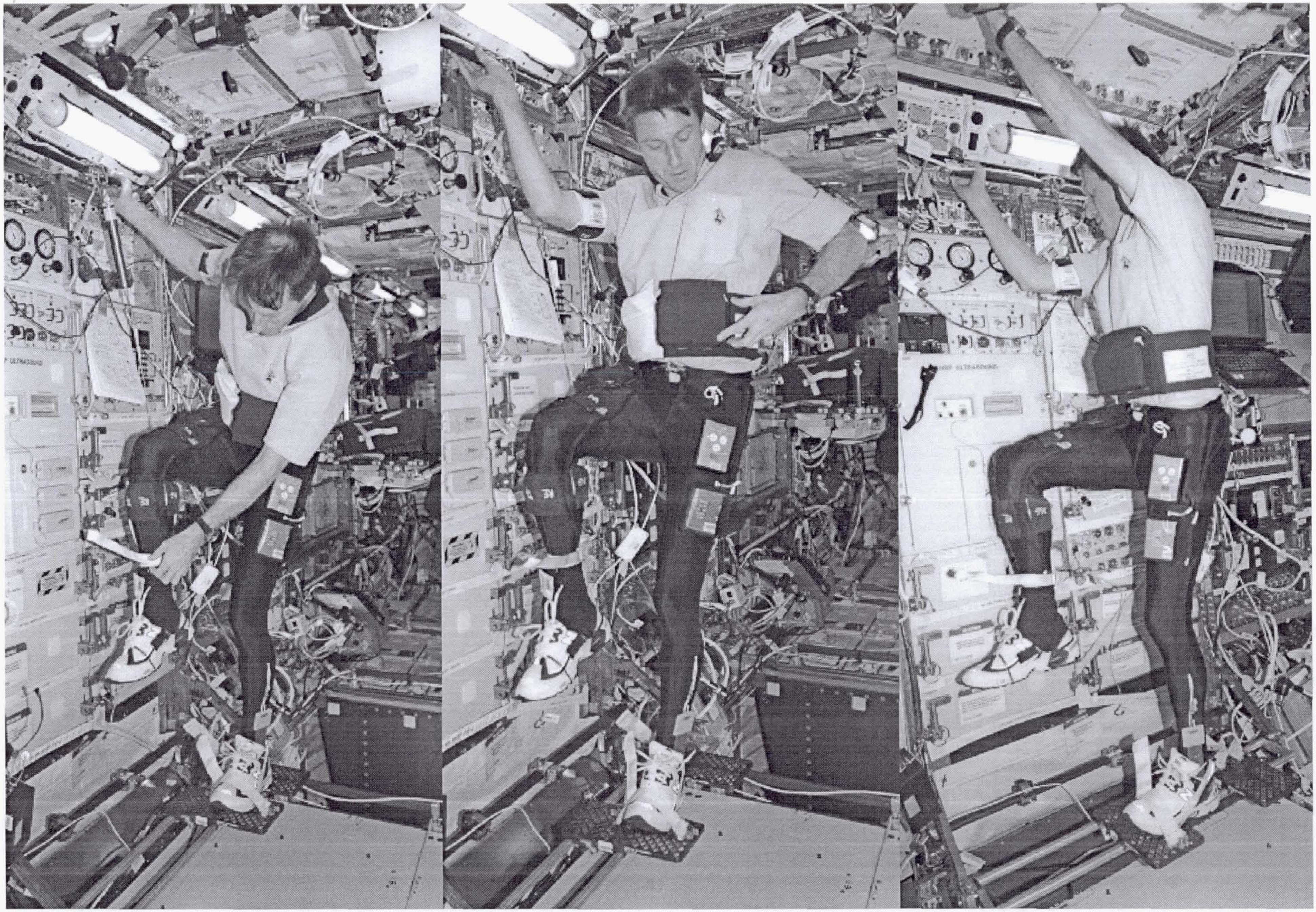

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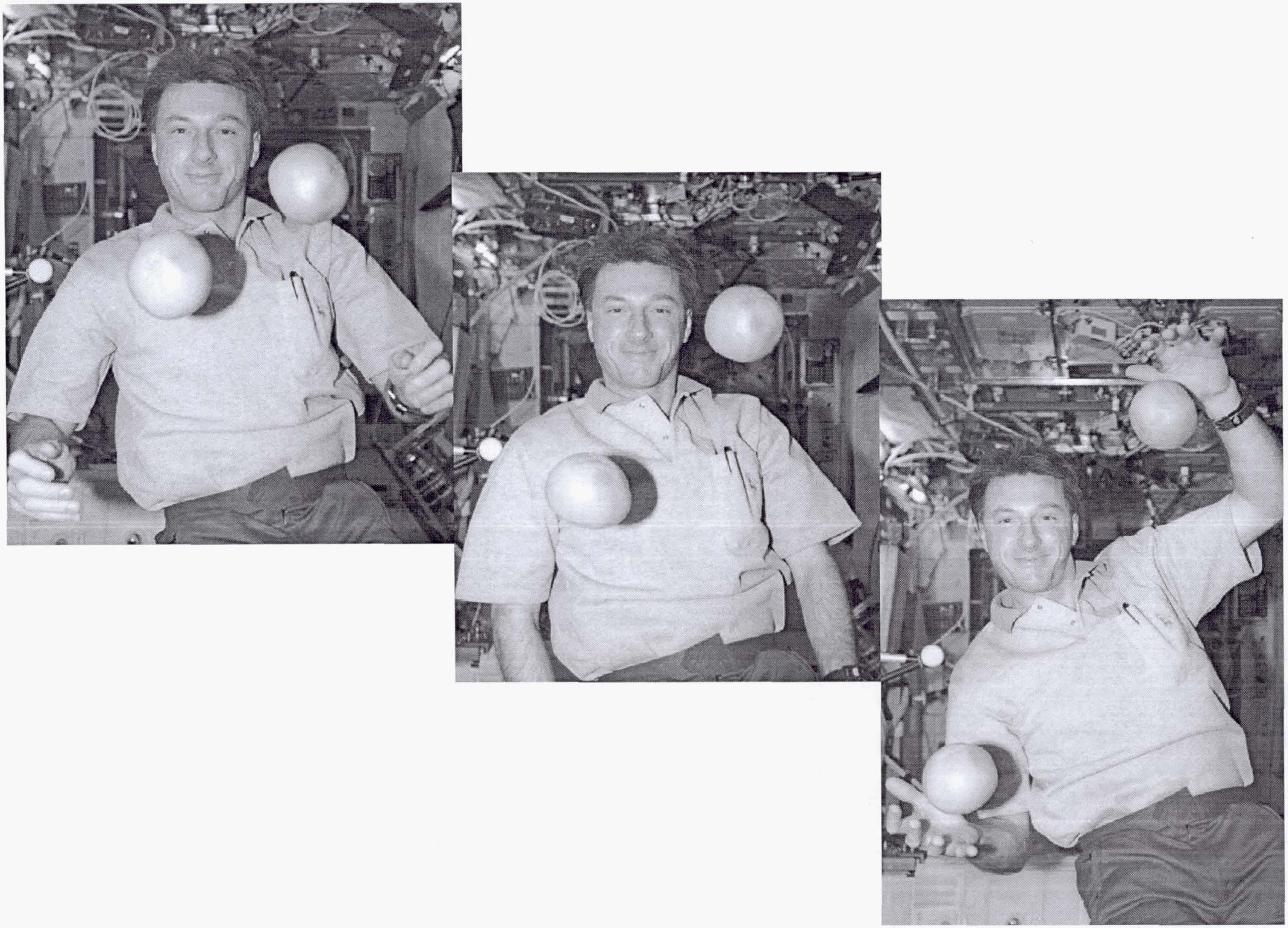
PORT



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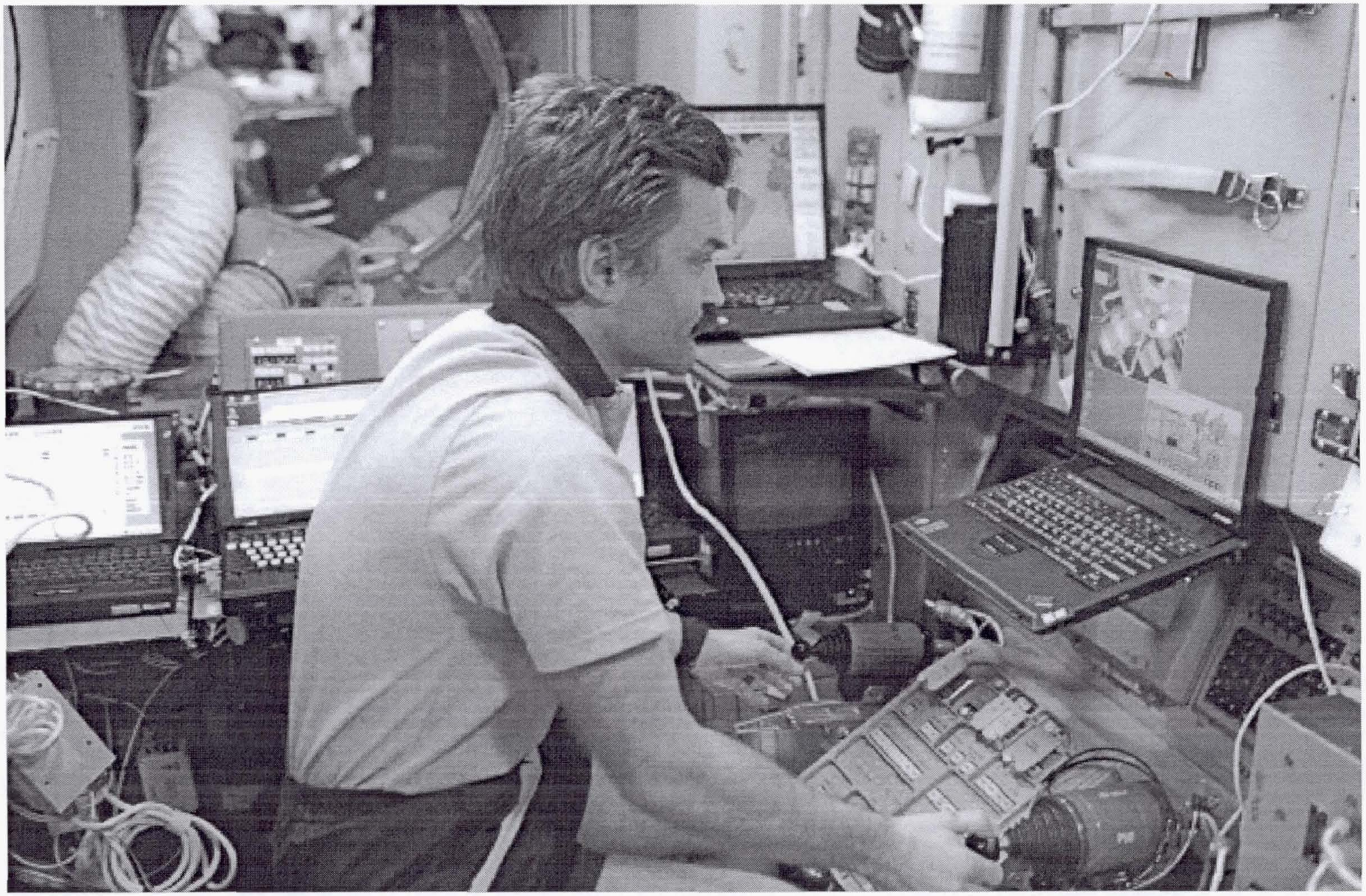

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HATCH
STBD
DELTA

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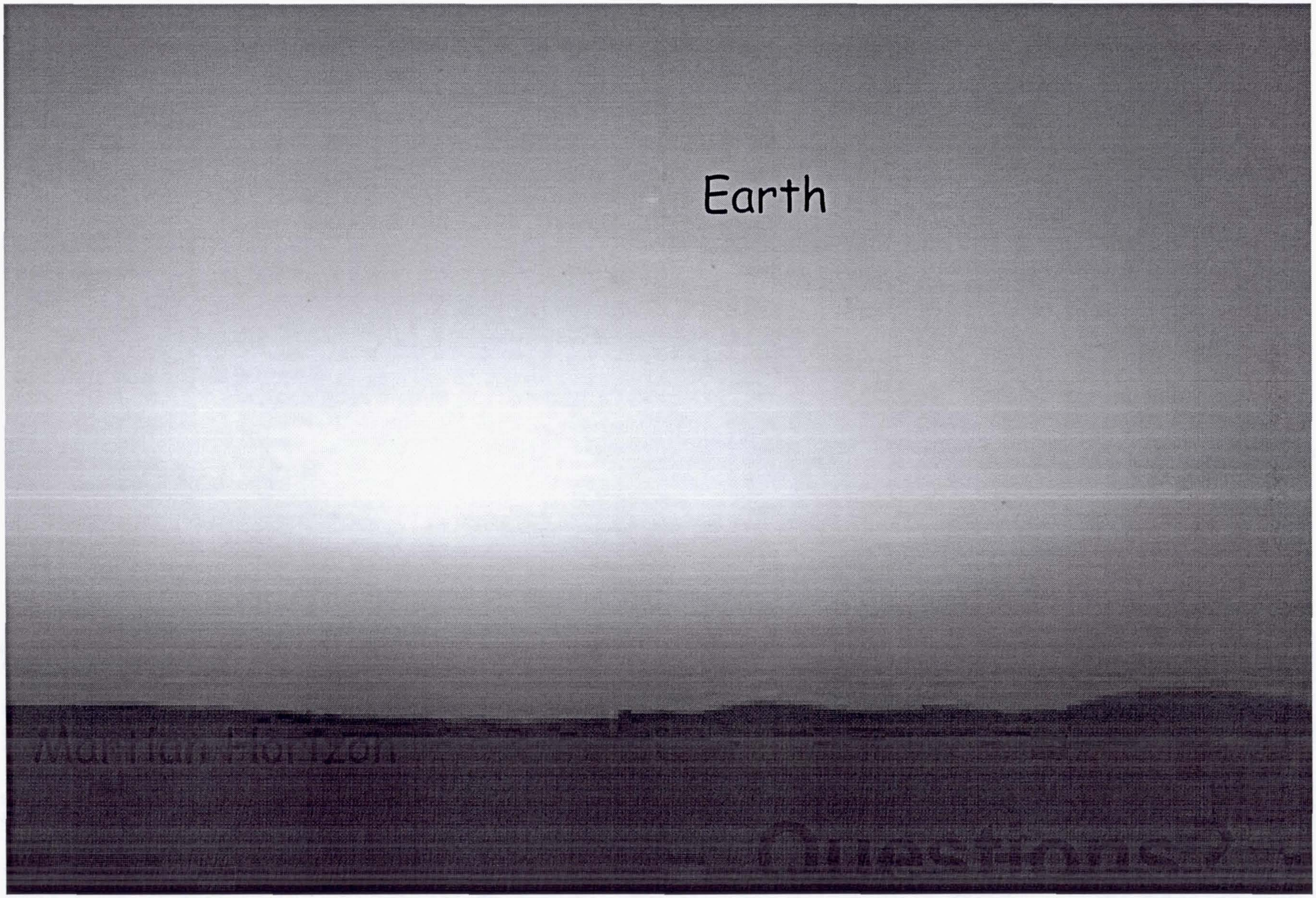
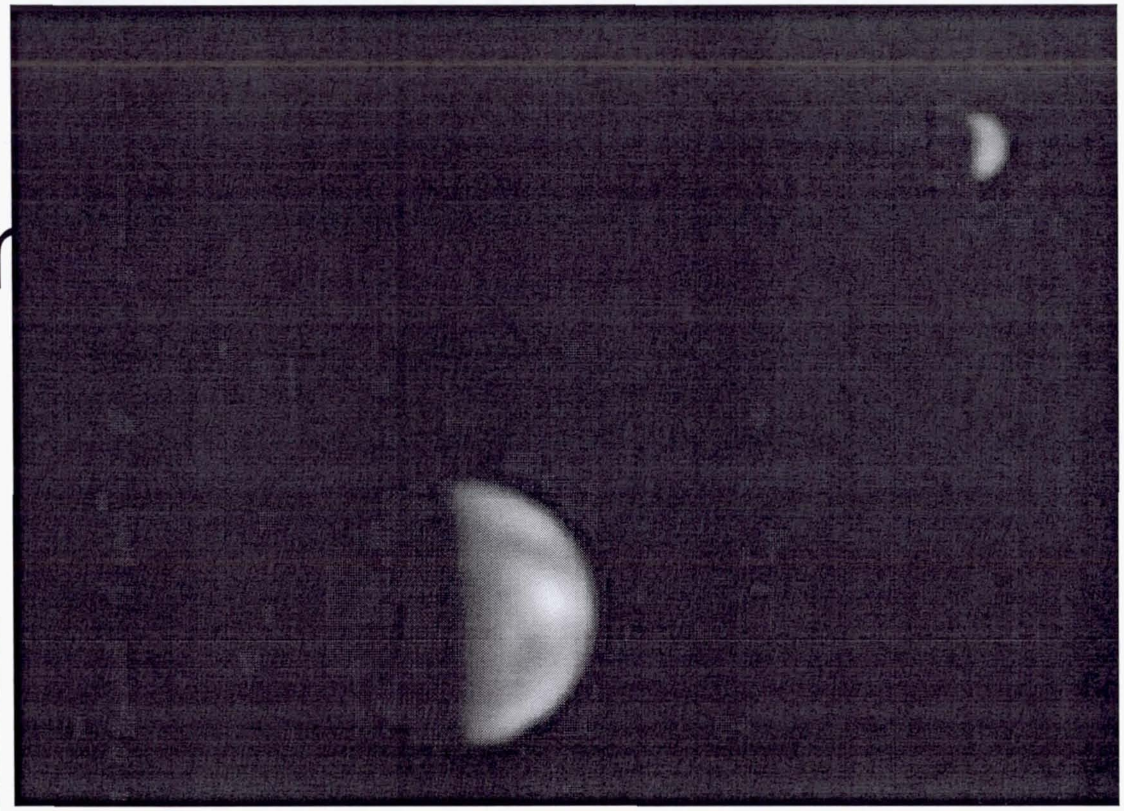
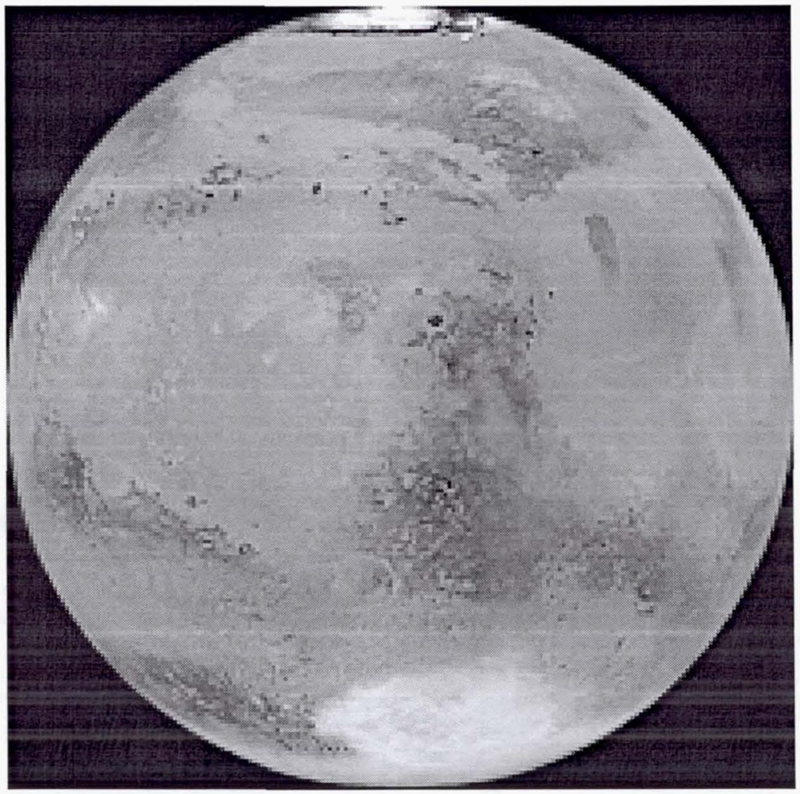
Sun setting over Earth

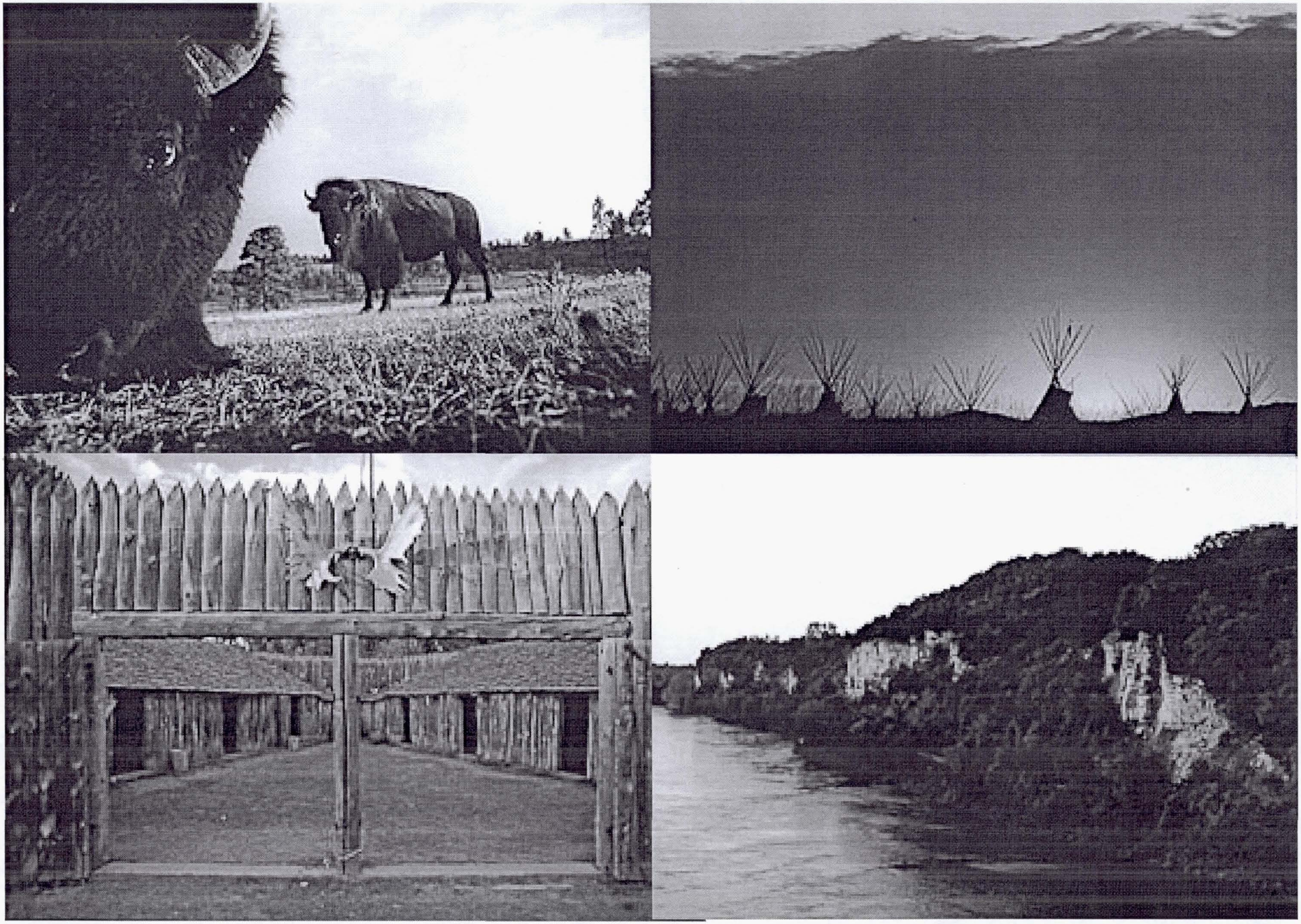

Sun setting over Mars


Earth
Martian Horizon

Backgrou







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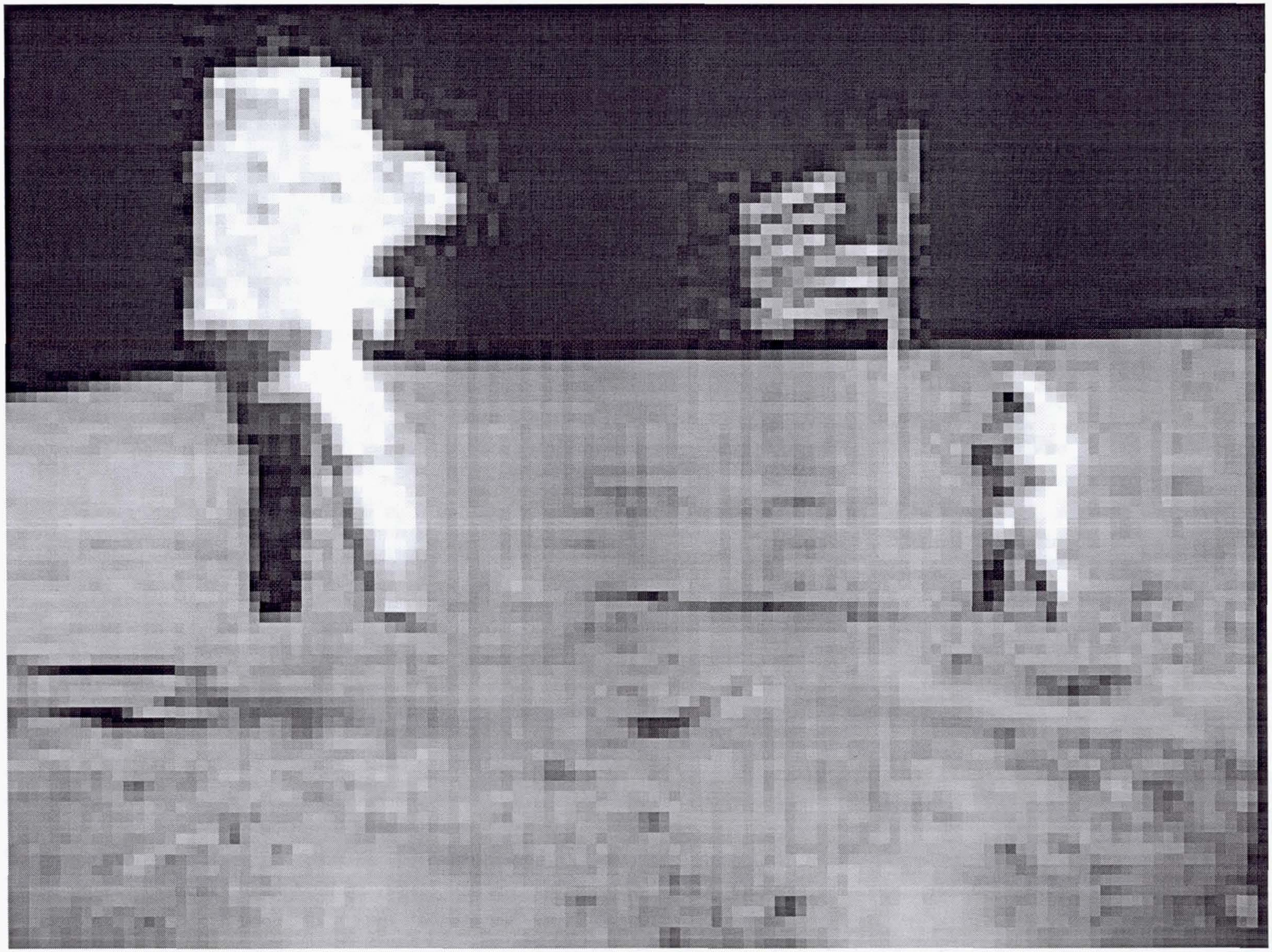

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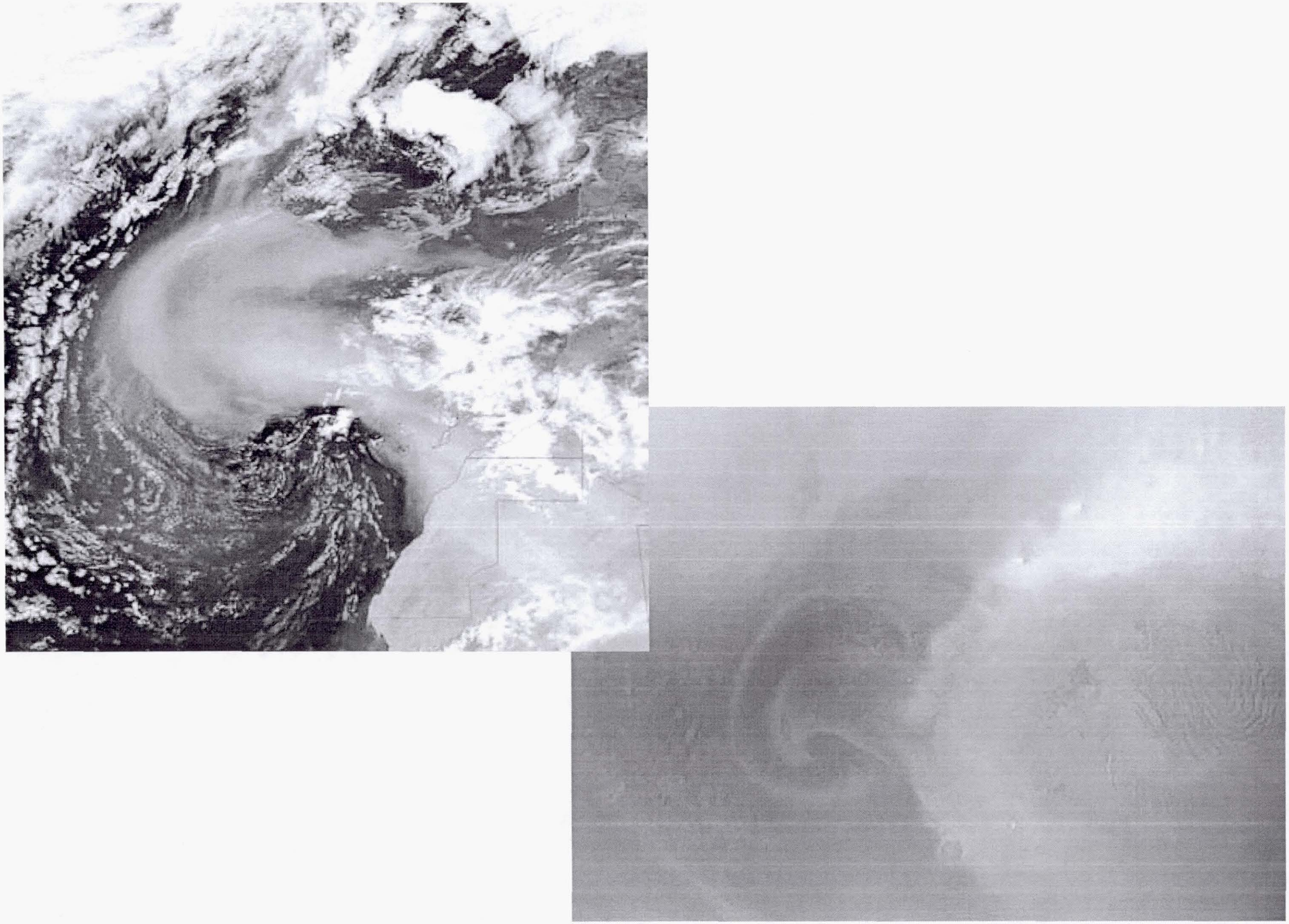

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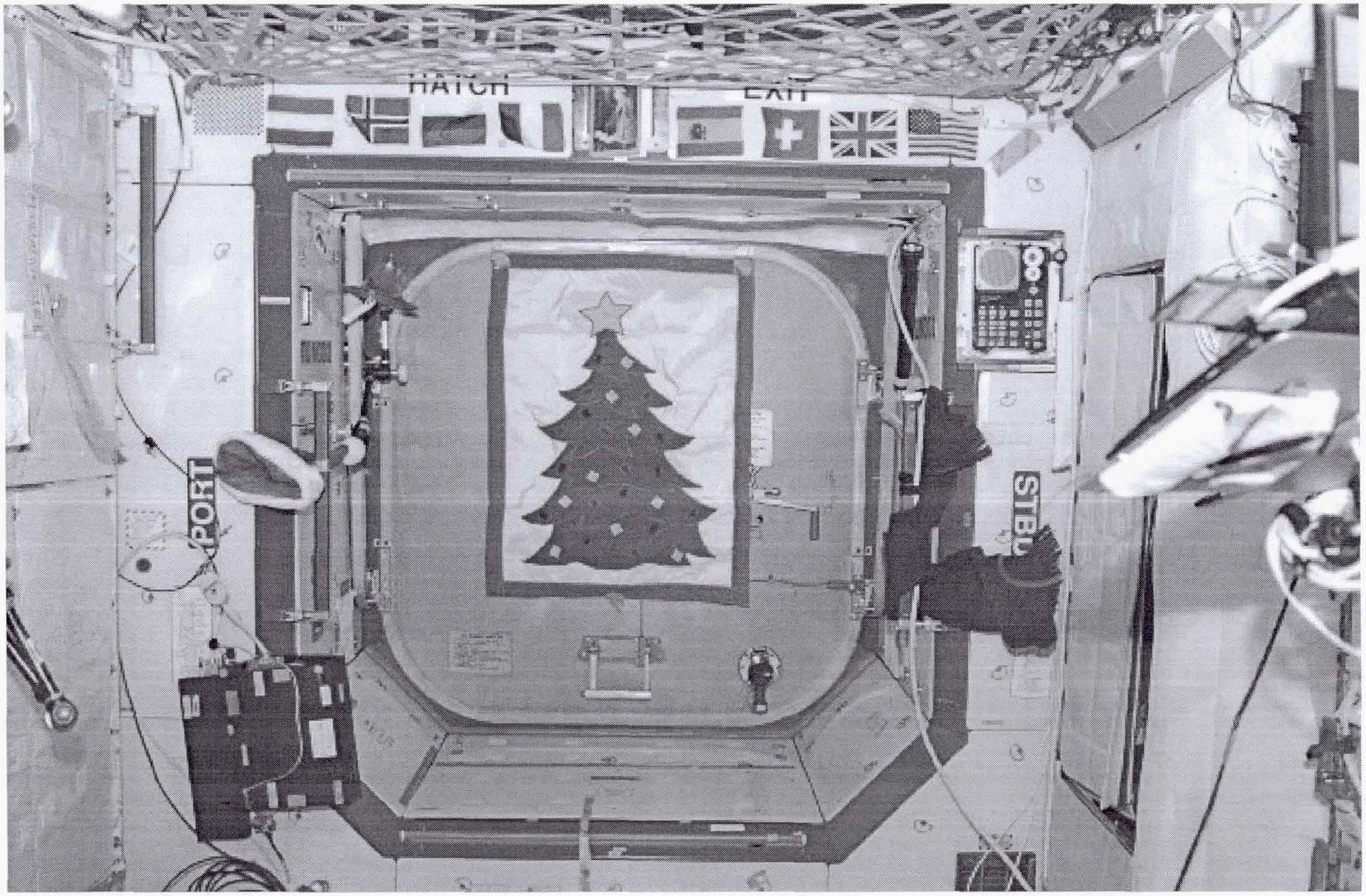
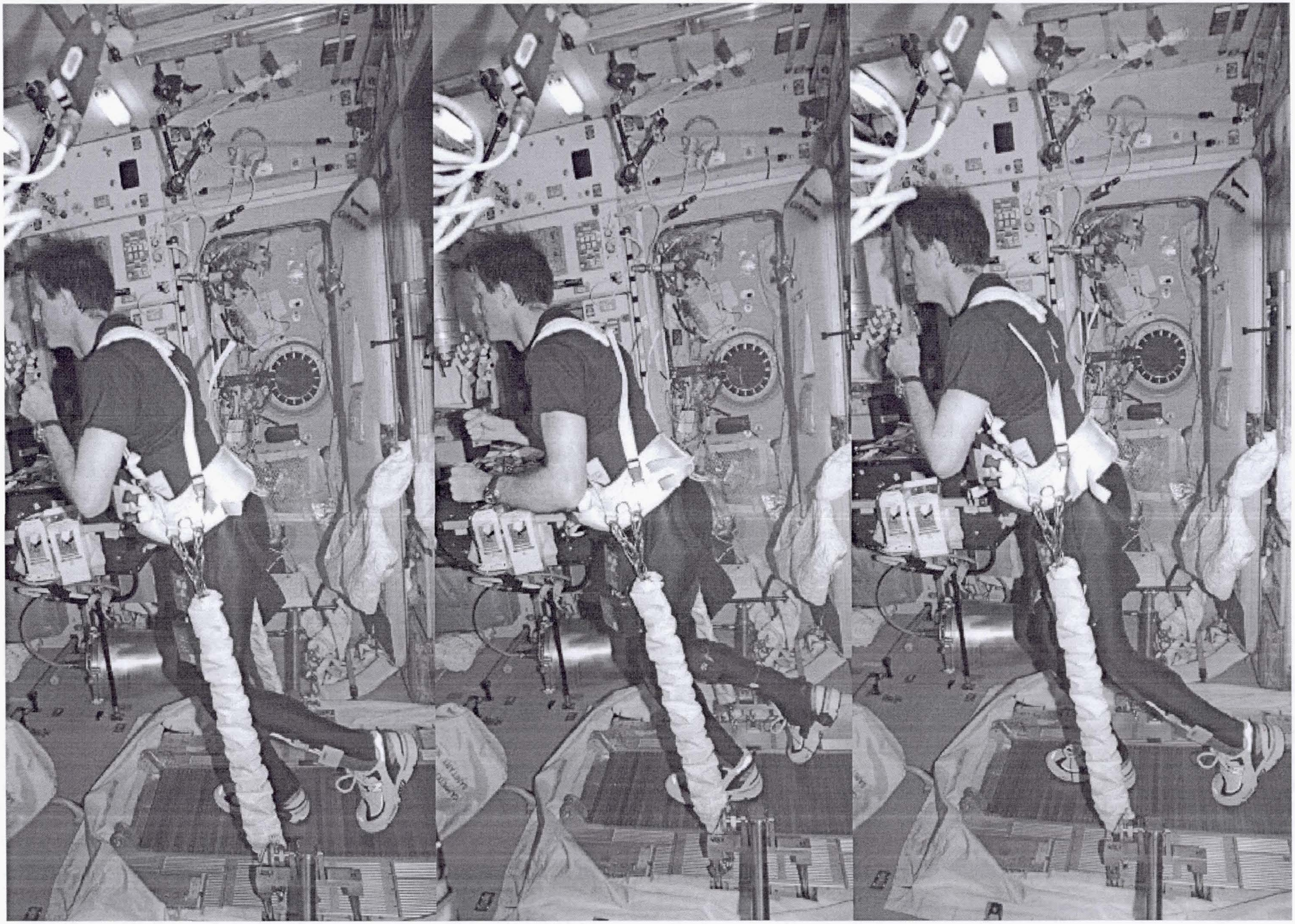

HATCH
EXIT
PORT
STBD



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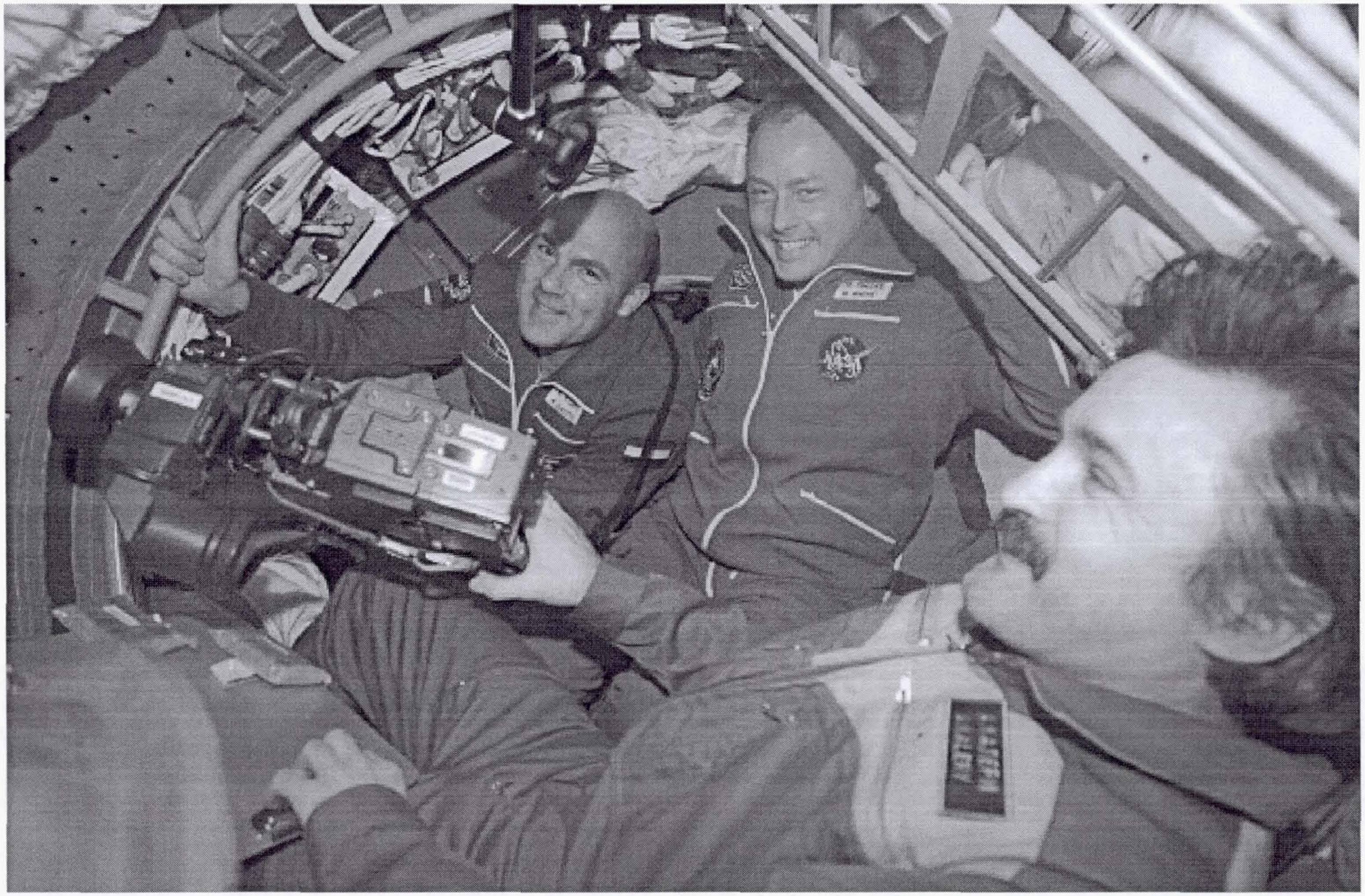
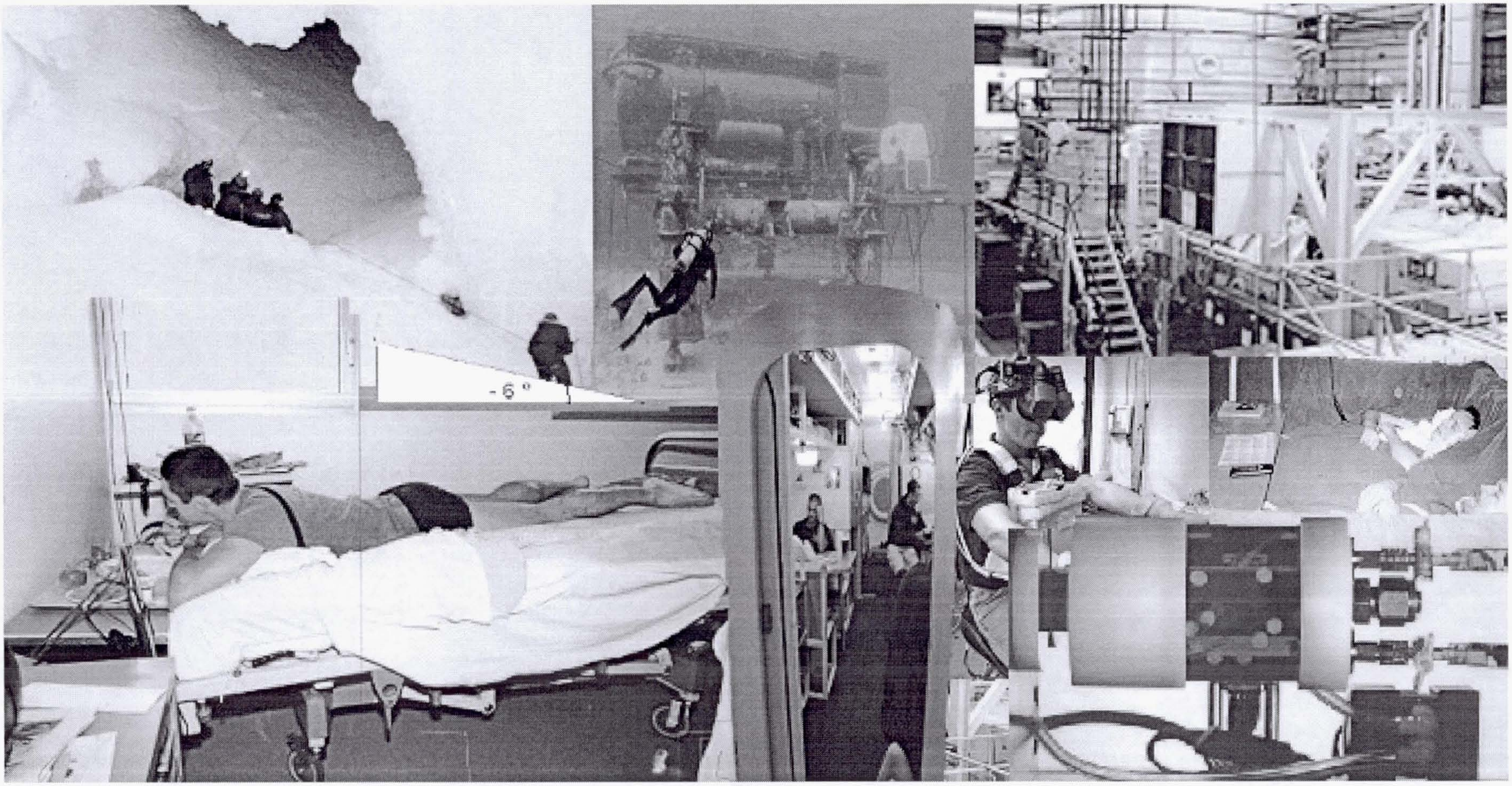


Space Flight Analogs



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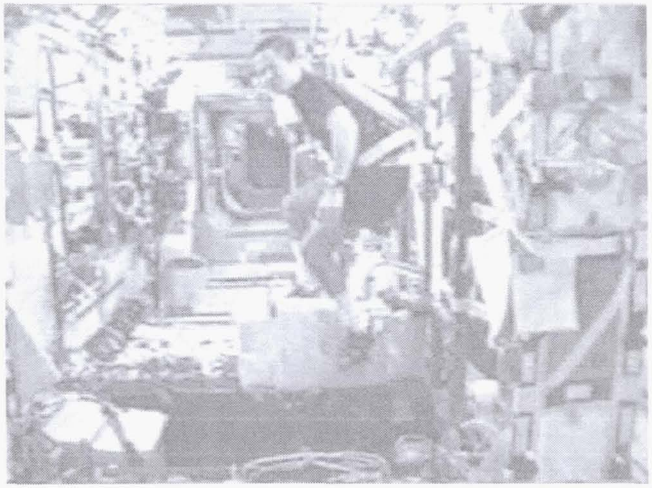
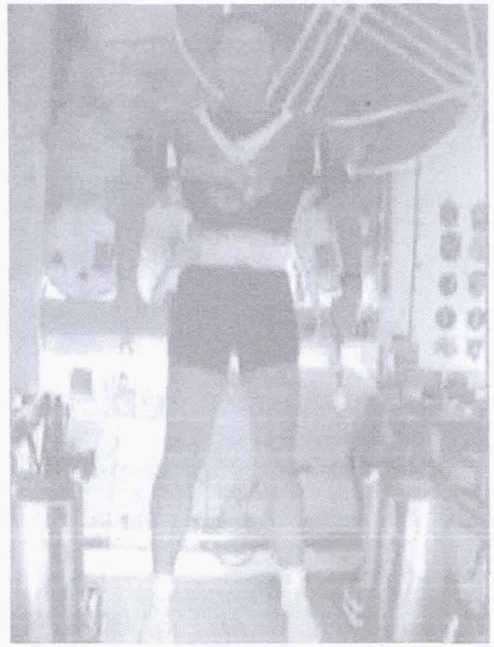
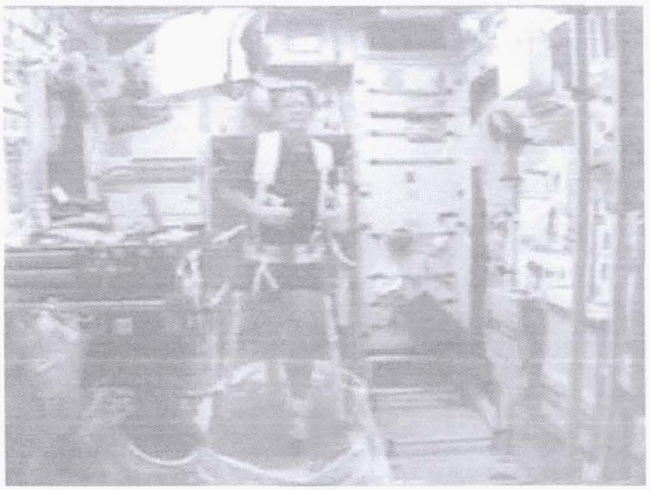
Countermeasures



CEVIS



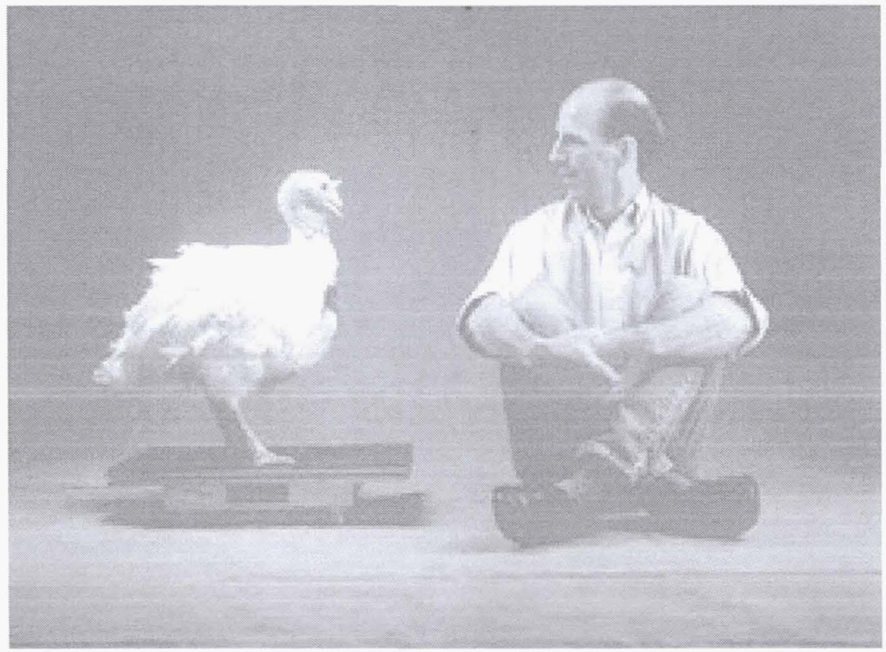
iRED



TVIS

Vibrating plate

- 90 Hz (1 Hz = 1 cycle per second)
- Brief oscillation imparting an acceleration equivalent to 1/3 G
- Subjects
  - Turkeys
  - Sheep
  - Rats



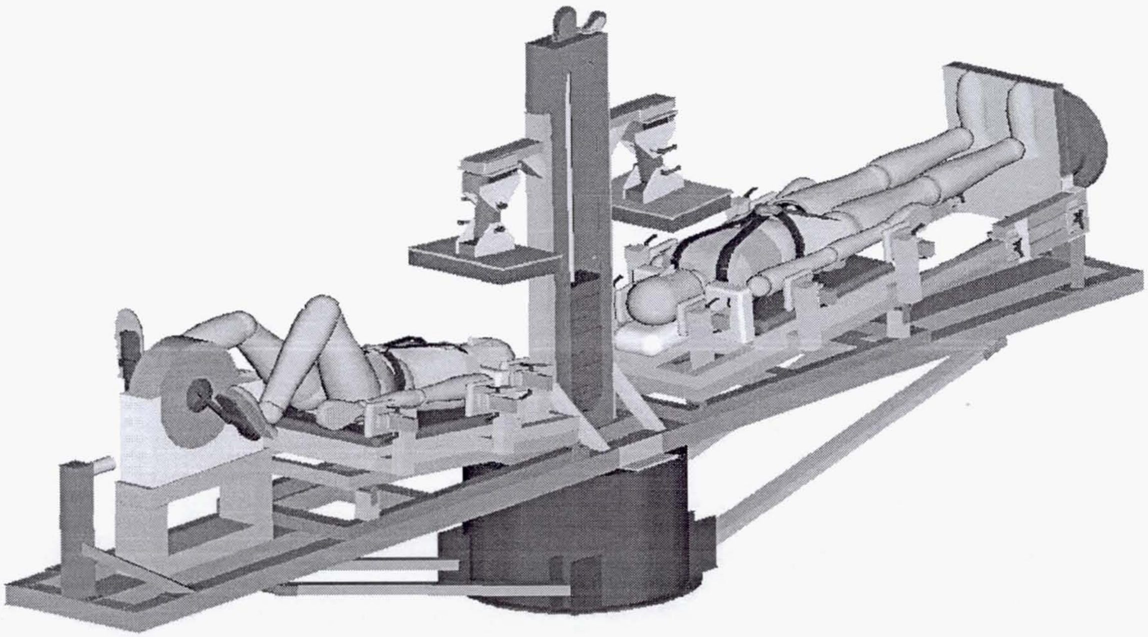
Artificial Gravity Study
Short-arm Centrifuge

Protocol

- Bedrest for 21 days
- Active subjects transferred supine to a short radius centrifuge
  - Rotated at +2.5 gz (at the foot) for 1 hour per day
- Control subjects remain in bed

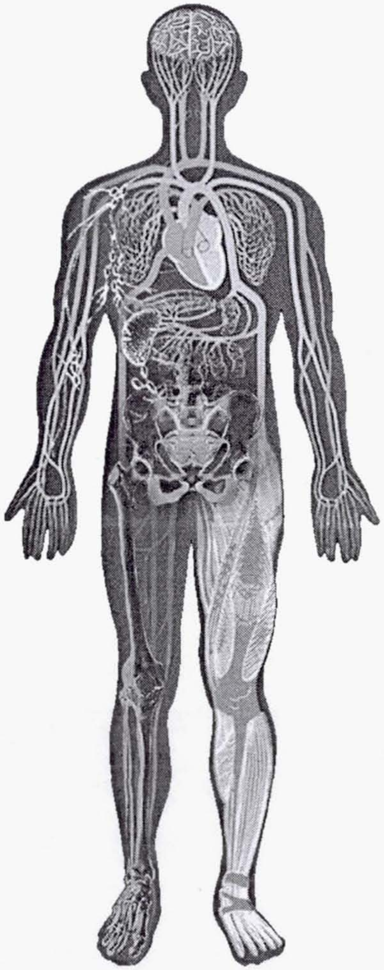
International Multi-system AG Bed Rest (IMAG)

- Centripetal acceleration
- Head-to-foot gravity gradient
- Angular velocity
- Tangential velocity
- Cross-coupled head rotations
- Coriolis effects



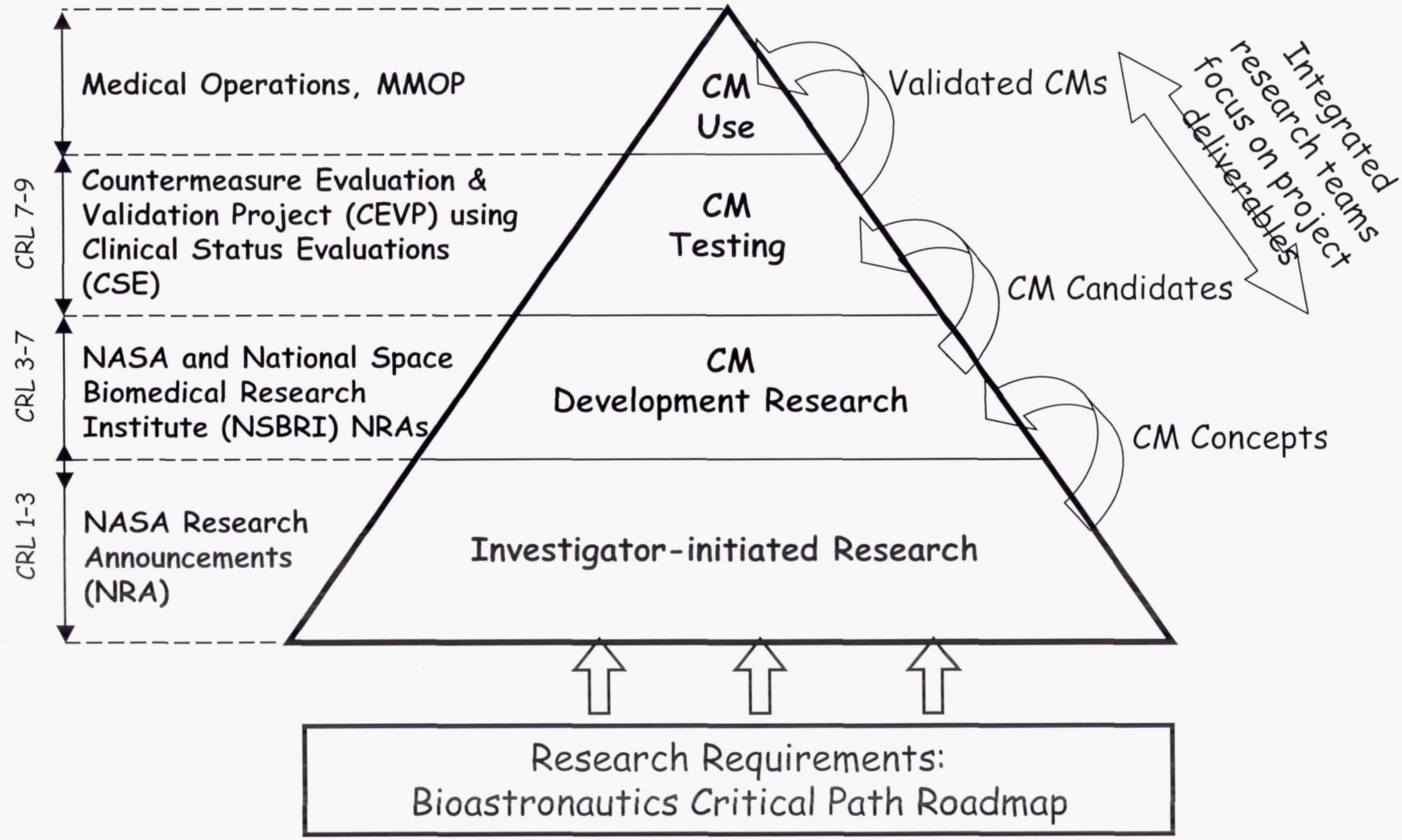
Effects of Microgravity on Human Physiology

- Radiation effects
  - Carcinogenesis
  - Cataracts and other degenerative tissue effects
  - Genetic changes
  - Fertility, sterility changes
- Bone loss
  - Acceleration of osteoporosis
  - Fracture and impaired fracture healing
  - Injury to soft connective tissue, joint cartilage, and intervertebral disc
  - Renal stone formation
- Behavior and performance
  - Environmental, individual, group, and organizational
  - Performance decrements/enhancements

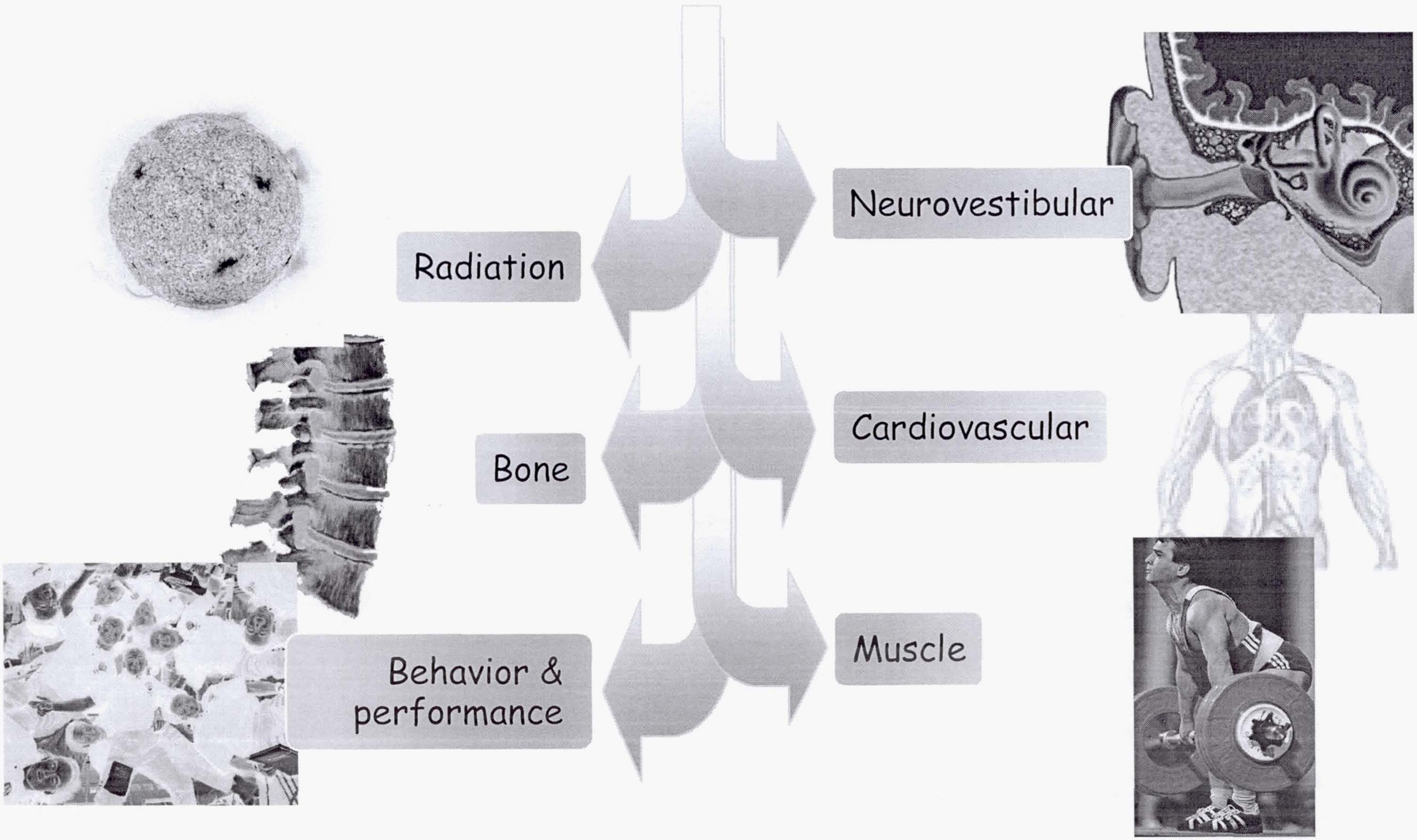


- Neurovestibular adaptations
  - Perception and orientation
  - Posture
  - Vertigo, nystagmus, oscillopsia
- Cardiovascular changes
  - Aerobic capacity
  - Cardiac dysrhythmias
  - Orthostatic intolerance
  - Diminished cardiac function
- Muscle changes
  - Atrophy and loss of muscle strength
  - Morphological changes in muscle biopsies
  - Poor coordination
  - Loss of leg volume

Bioastronautics Critical Path Roadmap



Extended Weightlessness

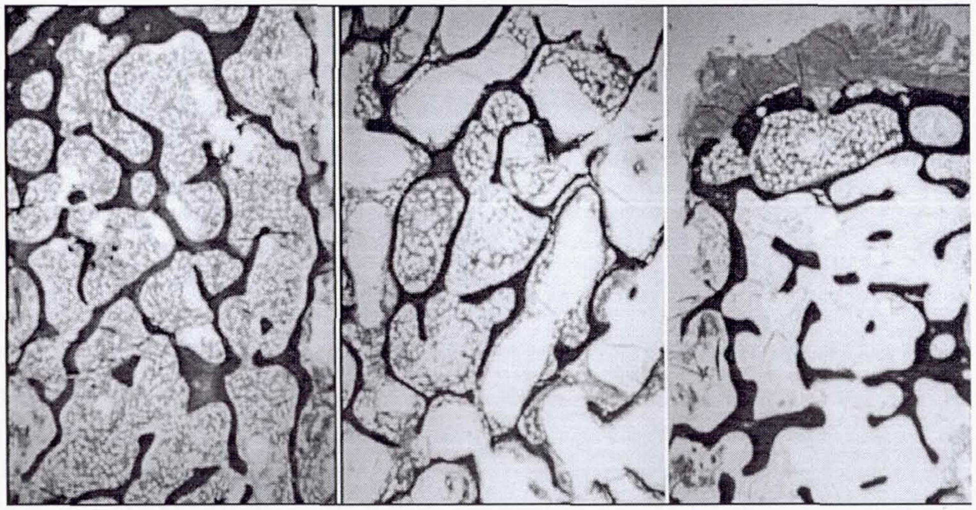


Radiation

- Occurrence
  - All space travelers are subjected to radiation
- Due to
  - Galactic cosmic rays
  - Protons and electrons trapped in Earth's magnetic field
  - Solar particle events
- Consequences
  - Cataracts
  - Cancer
  - Central nervous system damage
  - Acute radiation sickness

Bone

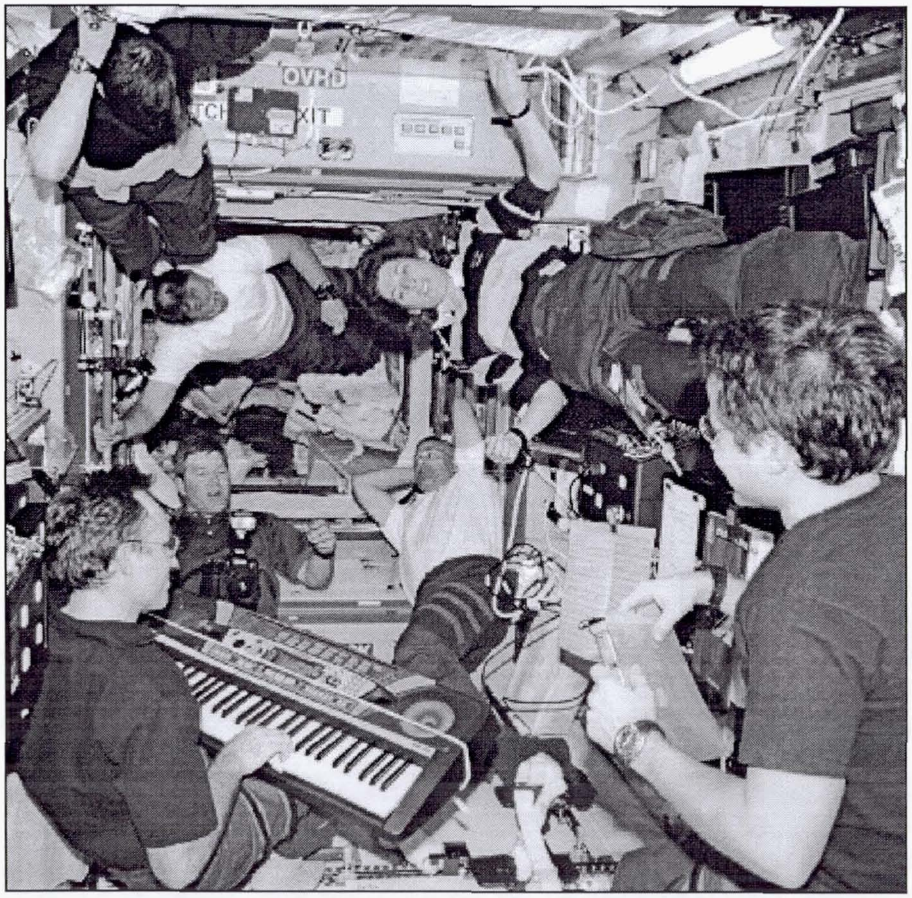
- Occurrence
  - Osteoporosis occurs in 100% of astronauts at a rate of 0.4% to 1% per month
  - Over a period of 2 to 3 years postflight, bone recovery occurs in most but not all individuals
- Due to
  - Skeletal unloading
  - Interplay among biomechanical factors, hormonal and metabolic balance
- Consequences
  - Increases clinical risk of
    - stress/traumatic fractures
    - impaired fracture healing
    - soft tissue injury
    - renal stone formation



Normal Thinning Osteoporotic

Behavior and Performance

- Occurrence
  - All subjected to factors that affect
    - Psychological well-being
    - Interactions with other crewmembers, families, and ground personnel
    - Performance of duties
- Due to
  - Mission design
  - Events
  - Spacecraft environment
- Consequences - changes to
  - Interpersonal environment
  - Safety and productively
  - Team problem solving
  - Decision making
  - Communication

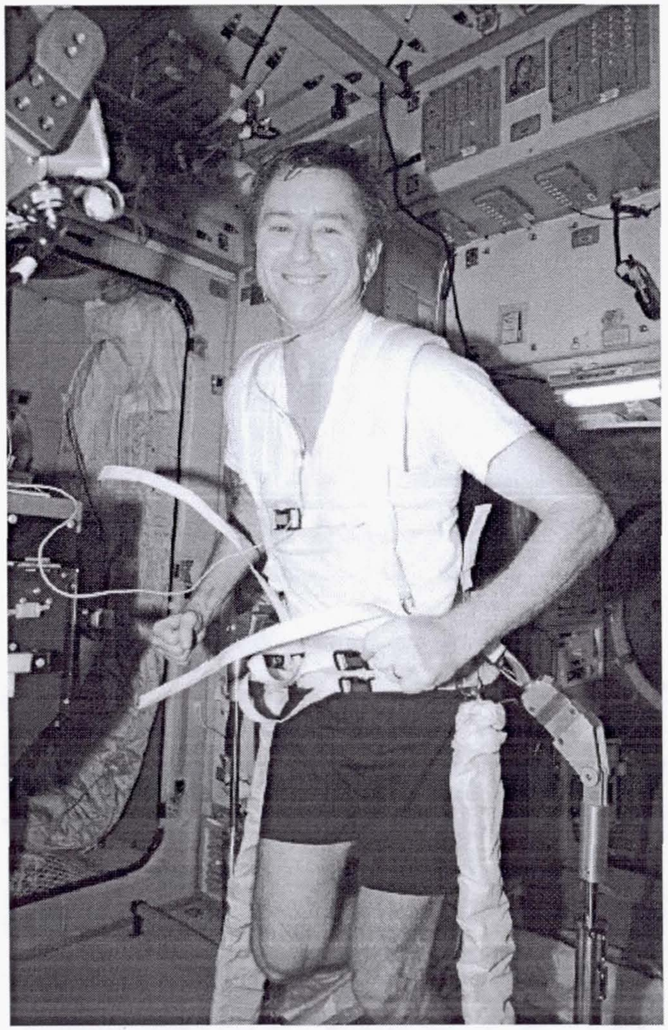


Cardiovascular

- Occurrence
  - In stages, early and later during flight
- Due to
  - Early during flight, fluid contained in the tissues and blood pools in upper body, triggering sensors to eliminate excess fluid
  - Blood volume and heart volume decrease, due to decrease in thirst and an increase in kidney output
- Consequences
  - Aerobic capacity decreased 10% to 20%
  - Blood volume and heart volume decrease
  - In 3 to 5 days, total body water stabilizes 2% to 4% below normal level and plasma volume decreases ~ 22%
  - >1 week, heart rate decreases and cardiac output increases

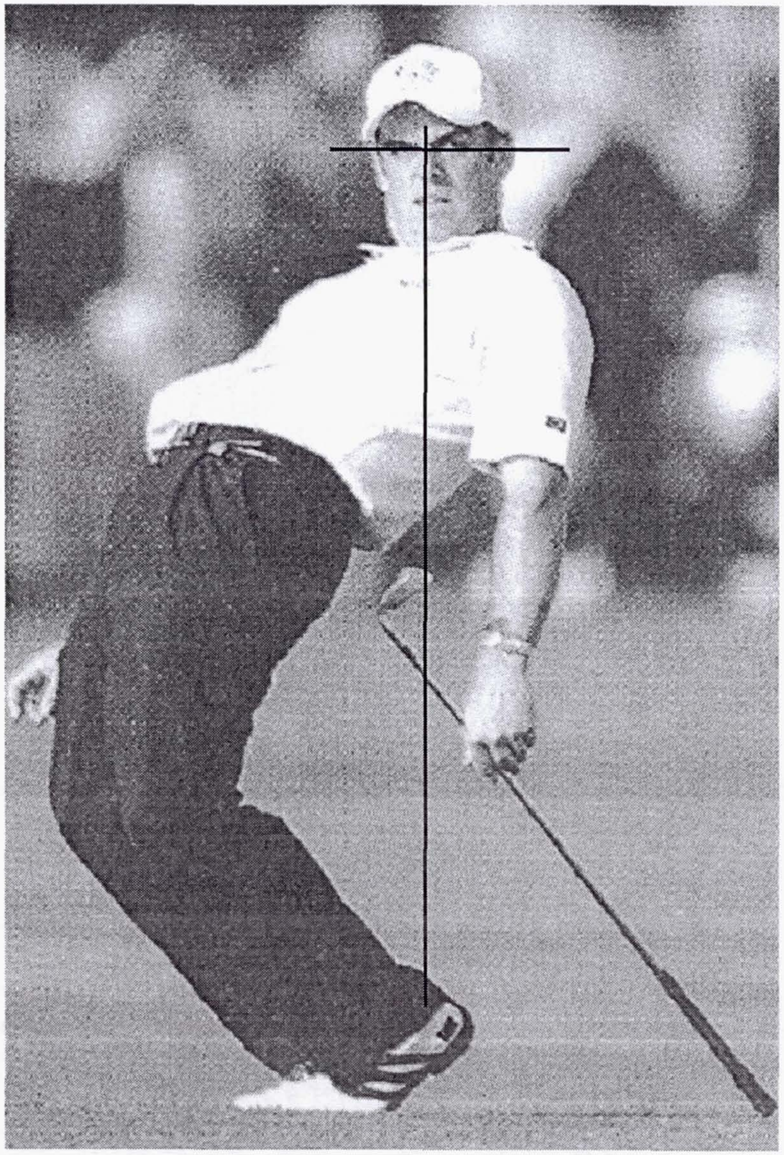
Muscle

- Occurrence
  - Muscles decondition most apparent in anti-gravity muscles
  - Continues unabated throughout flight
- Due to
  - Alteration in muscle protein synthesis
  - Lack of muscle loading
- Consequences
  - Results in loss of strength, power, and endurance
  - Increase in excretion of muscle breakdown metabolites (nitrogen, potassium, creatine, amino acids)

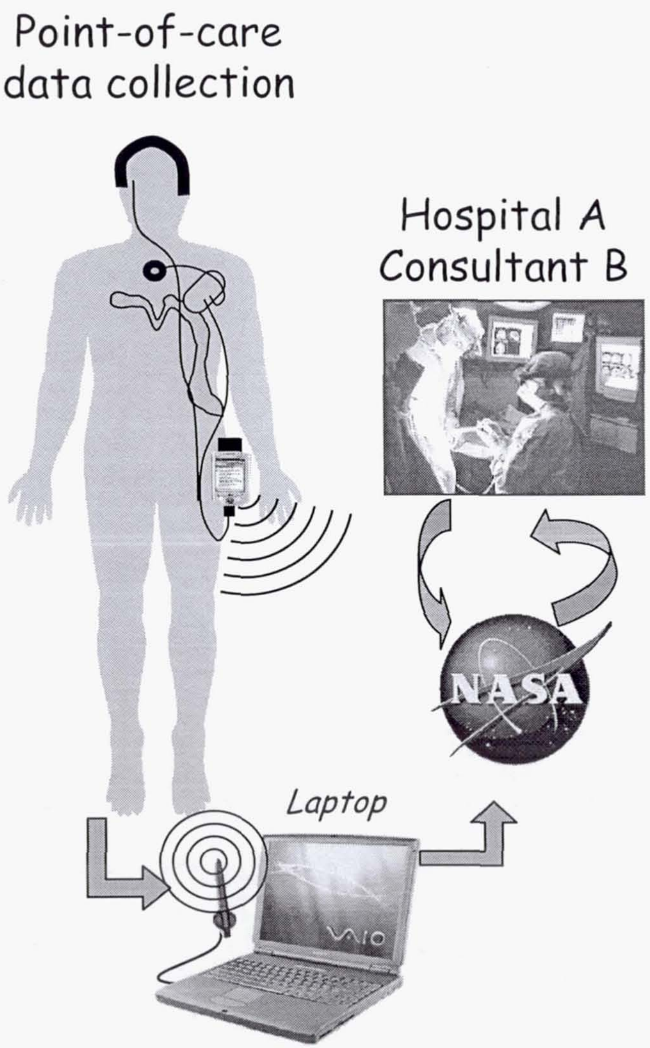


Neurovestibular

- Occurrence
  - 83% of first time flyers and 61% of repeat flyers on Shuttle
- Due to
  - Altered sensory stimulus
  - Rearrangement of signals from visual, skin, joint, muscle, and vestibular receptors
- Consequences
  - Disorientation
  - "Motion" sickness
  - Perceptual illusions (postflight feelings of heaviness)
  - Eye-head coordination disturbances (oscillopsia)
  - Balance control disturbances (postural ataxia)
  - Gait disturbances



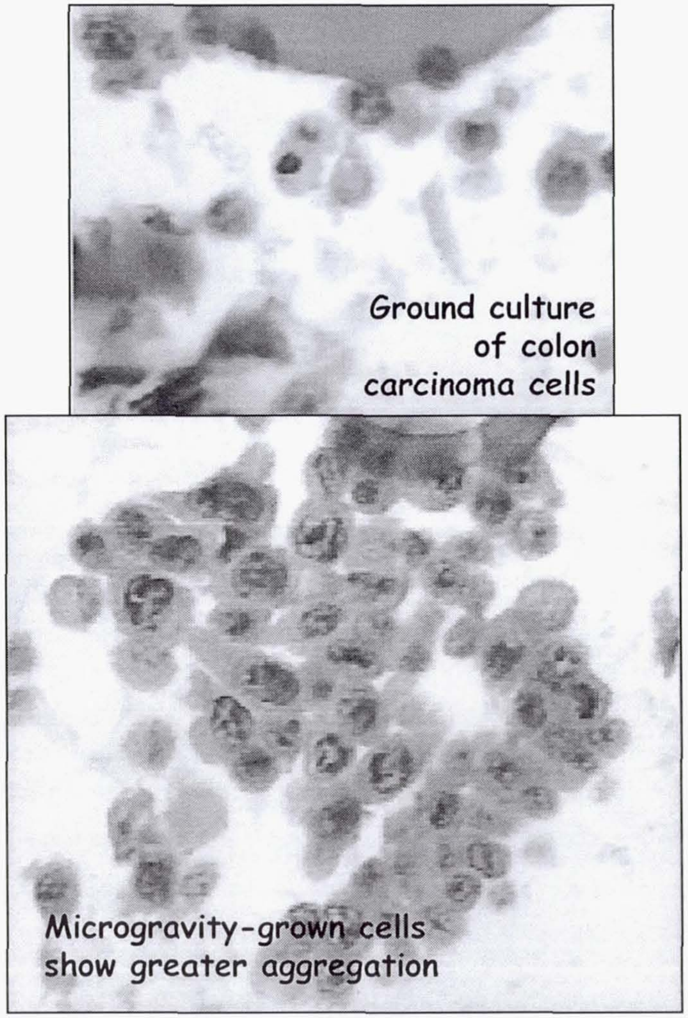
Autonomous Medical Care



- Occurrence
  - Pre, in, and postflight
- Due to
  - Health maintenance
  - Screening for astronaut selection
  - Preventing exposure to diseases
  - Medical and psychological monitoring
  - Use of countermeasures
- Consequences
  - Defined adaptive changes
  - Countermeasures to reduce the effects of these changes
  - Safeguards to health
  - Optimized performance

Solid-Body Rotation Culture

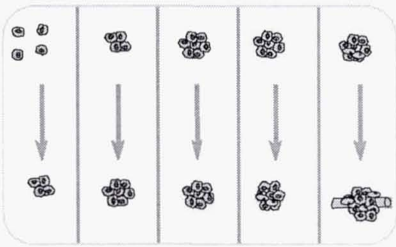
- 3-D propagation of tissue
- Greater frequency of successful co-culture
- May favor differentiation and/or de-differentiation
- Models some aspects of cell function in microgravity
- May increase ability to propagate otherwise "difficult" cells
- Production of novel biomolecules



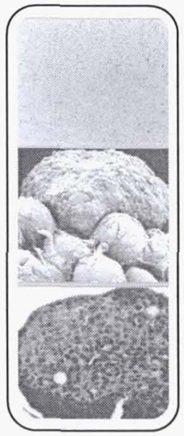
Cell Science

NASA technology and the microgravity of space

Tissue Engineering
Critical Stages



Models of Human Disease
Colon Cancer

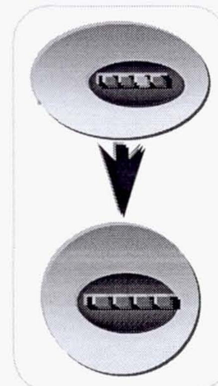


Vaccine and Drug Development
Microbial Growth

1g

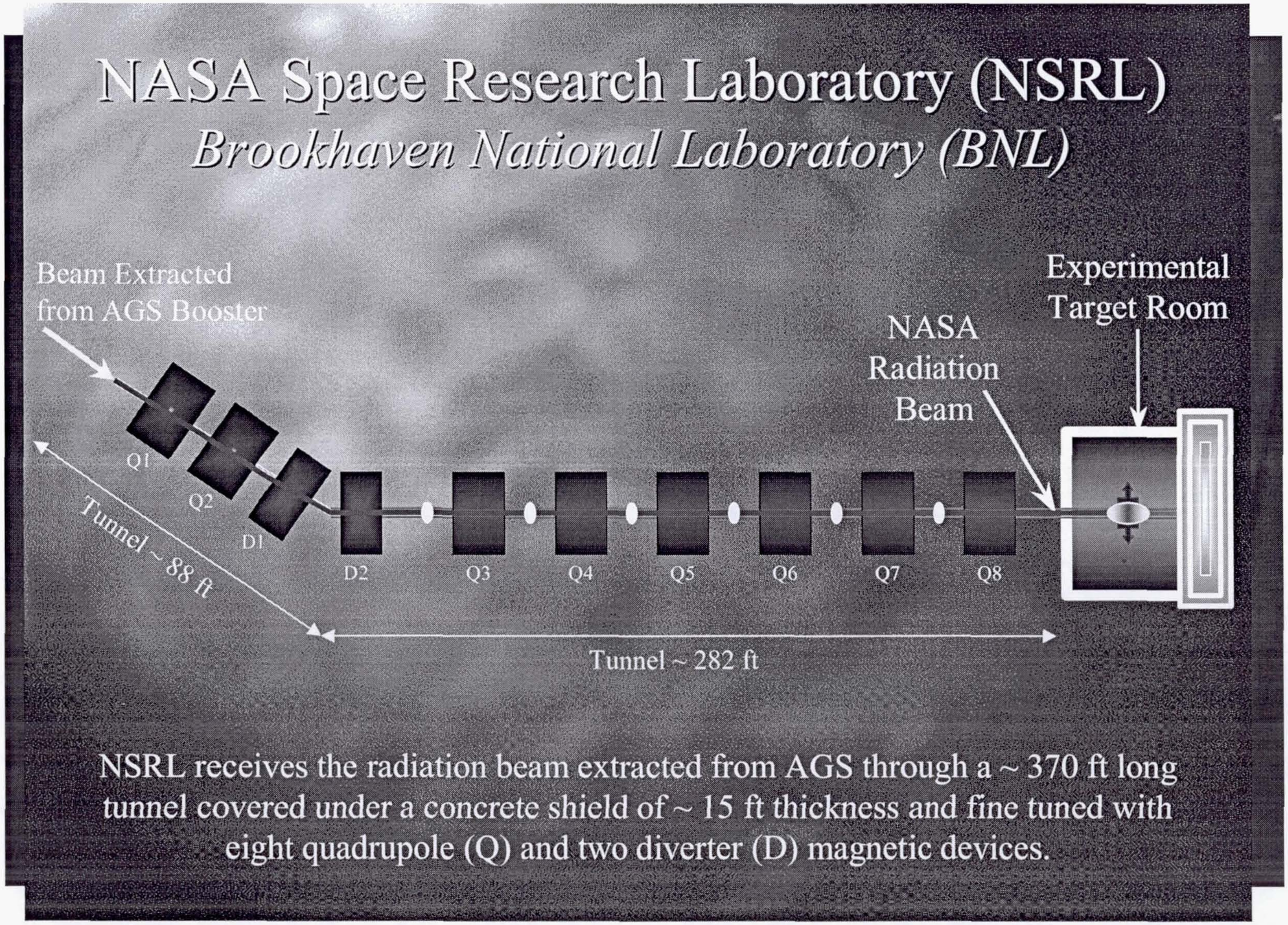
μg

Space Cell Biology
Gene Expression



Result in transplantable tissues, pharmacodynamic profiles, improved vaccines and biopharmaceuticals, microencapsulation, models of cell injury mechanisms, and antibody production mechanisms

Habitability & Environmental Factors



Biological Systems and Applications

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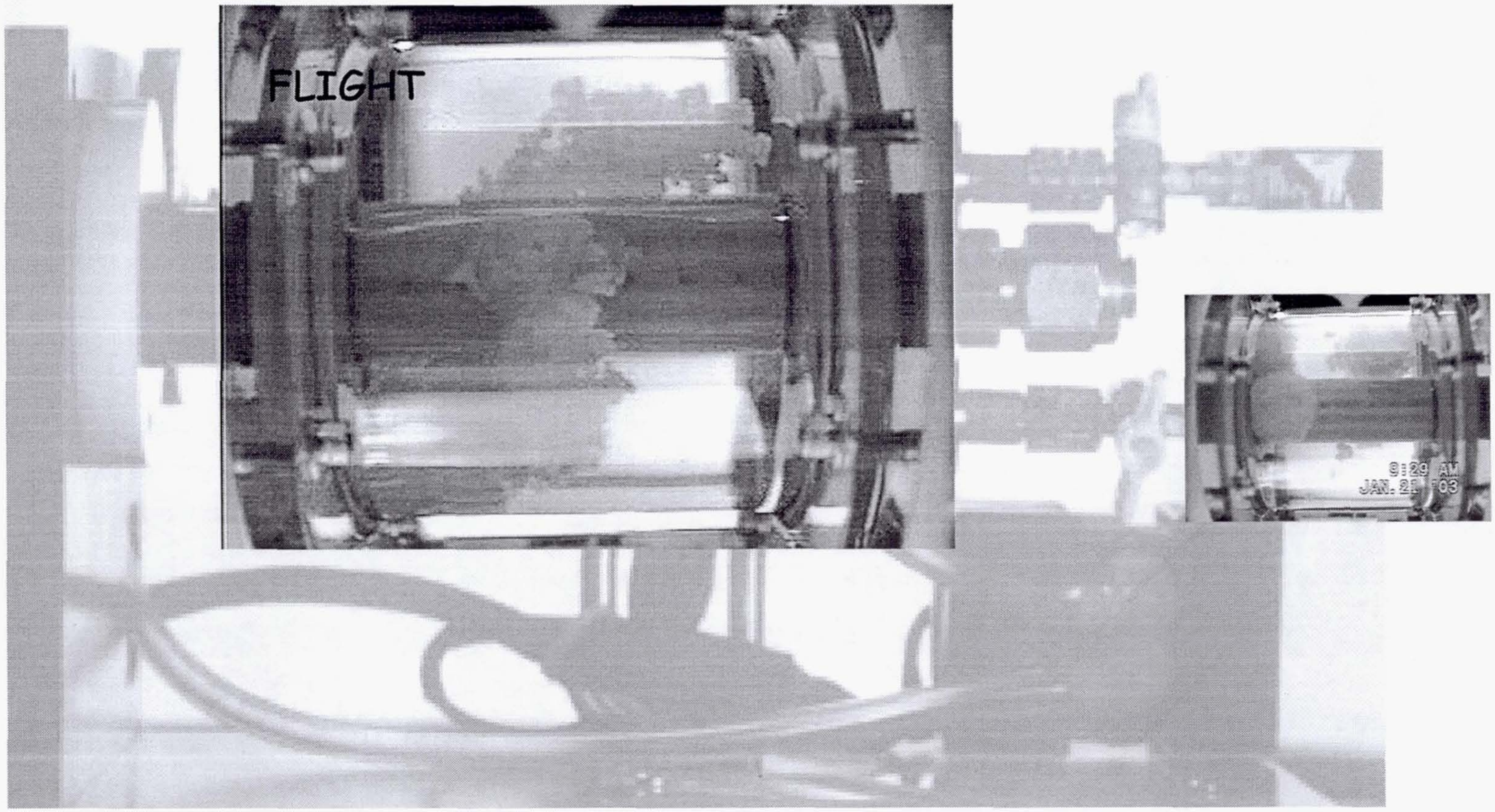
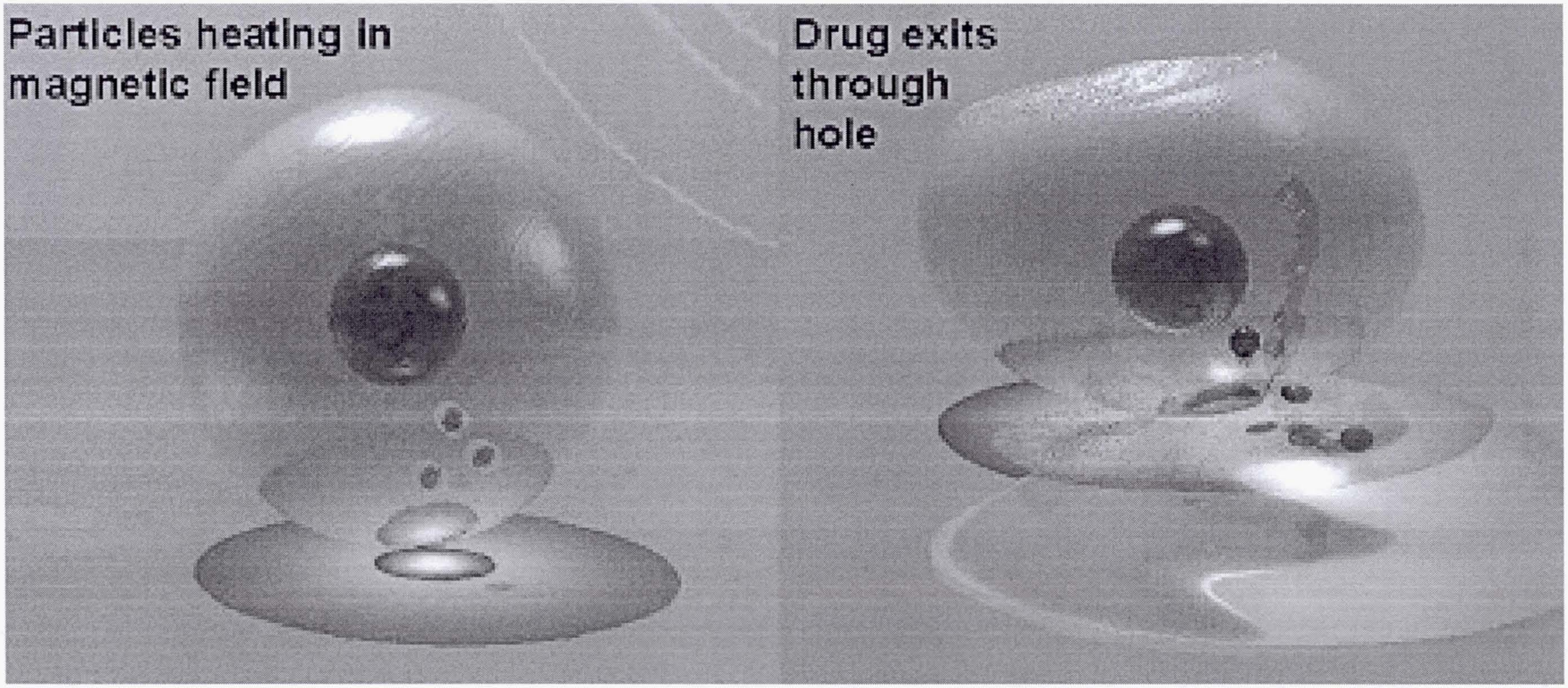
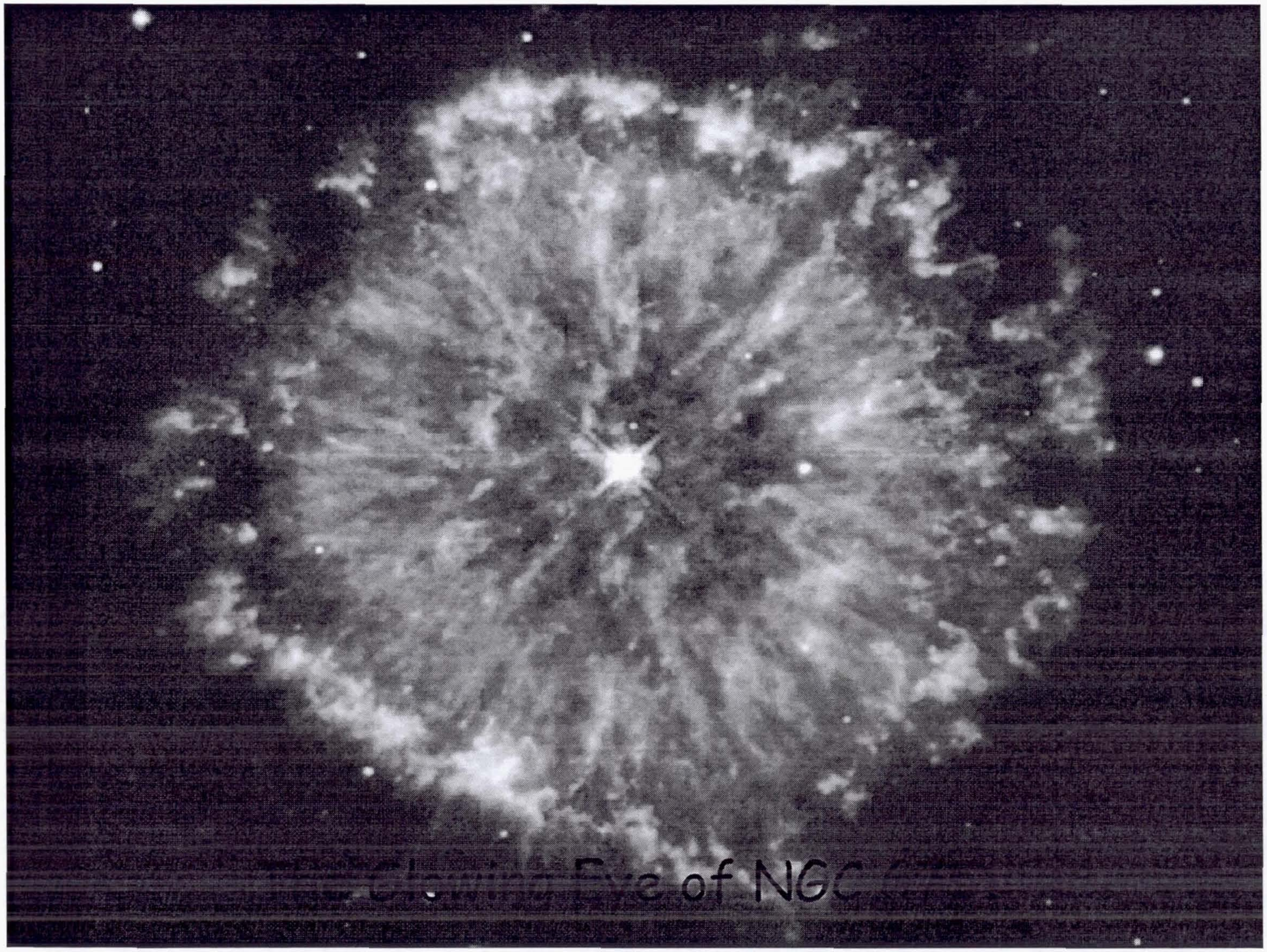


Biological Systems and Applications



Astromaterials Research and Exploration Sciences



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Spatial Orientation, Balance Control & Gravity

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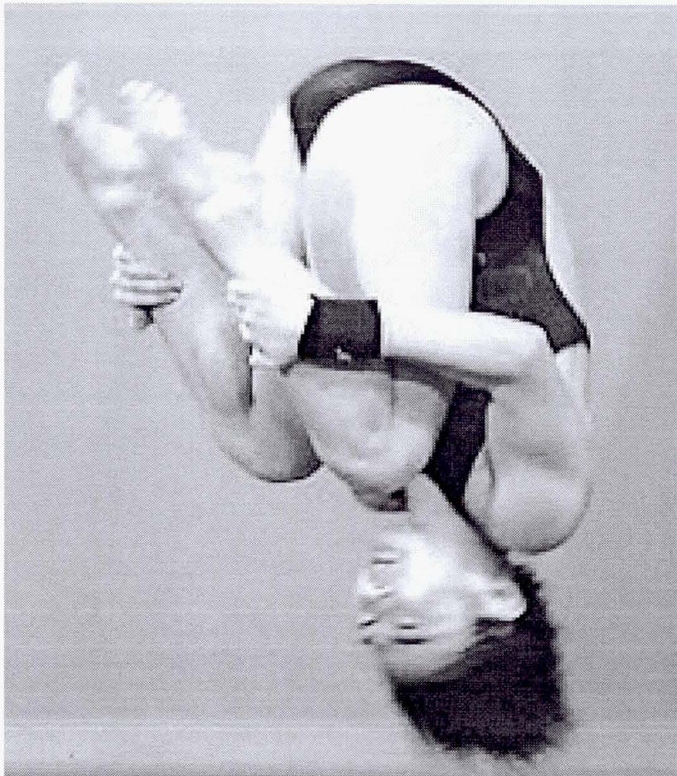

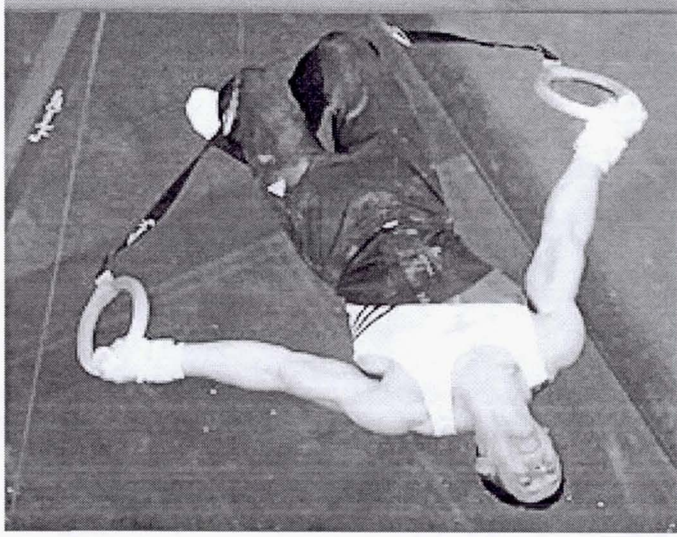

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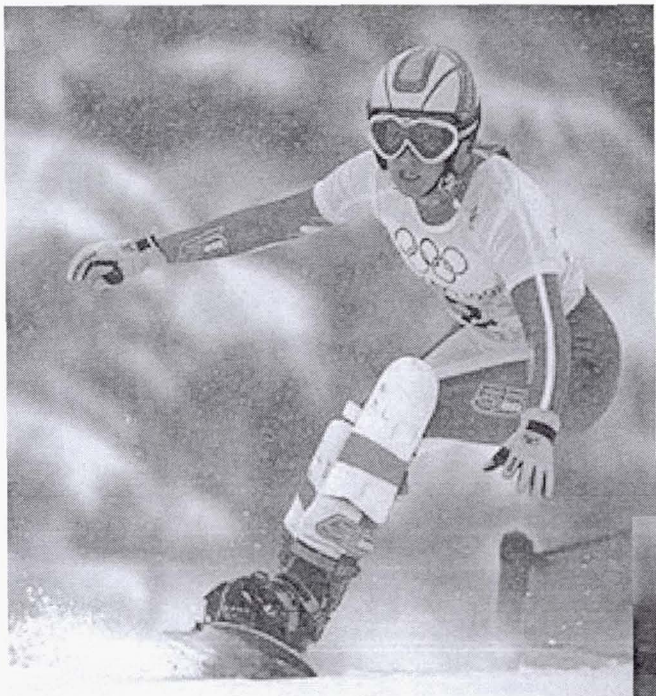

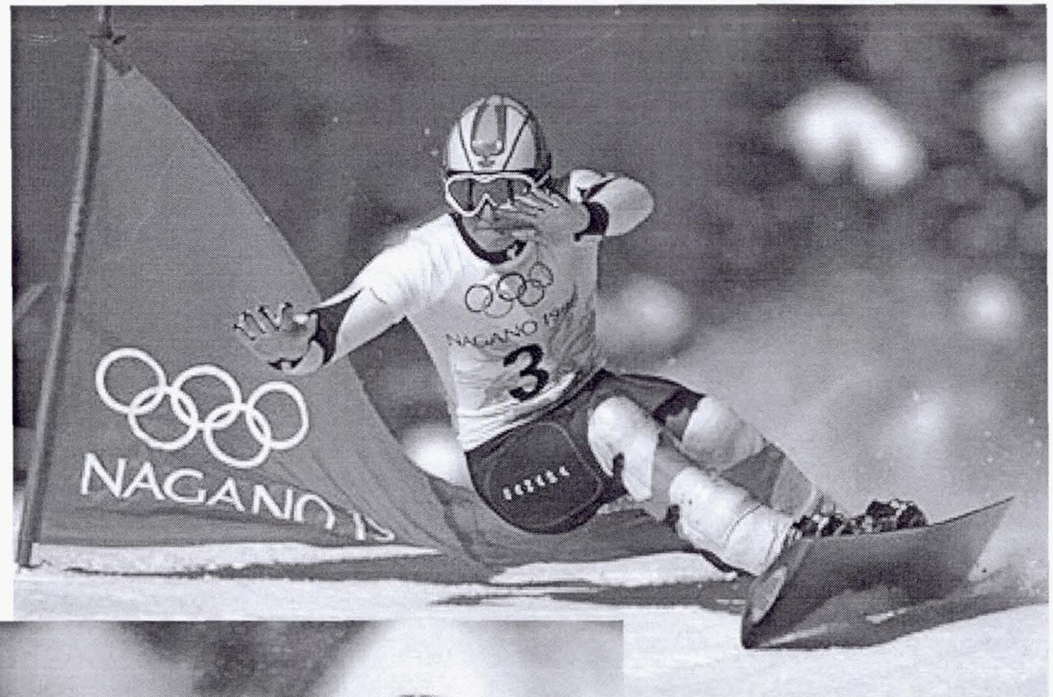

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